Sky and TELESCOPE

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COVER: Dunsink Observatory, the oldest in Ireland, stands on a hilltop near Dublin. On the roof of the main building is the dome of its largest telescope, a new 28-inch reflector; in the foreground is the housing of the century-old 12-inch refractor.

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Dunsink Observatory — Then and Now

DUBLIN was the astronomical capital of the world from August 29th to September 5th, when the International Astronomical Union met in Ireland as guests of the Dublin Institute for Advanced Studies. At this time, hundreds of astronomers from all parts of the world also visited the institute's observatory on the hill of Dunsink, seven miles from Dublin.

Dunsink Observatory is the oldest in Ireland, having been founded in 1780. Here, at the beginning of the last century, John Brinkley strove to measure the distances of stars, using a telescope whose pointings were indicated by a divided circle eight feet in diameter. It was as director at Dunsink that Sir W. R. Hamilton, Ireland's greatest man of science, made his searching contributions to mathematics and theoretical physics (see page 493).

There is a close link with America in the person of F. E. Brünnow, Dunsink's director from 1865 to 1879. He had earlier been the head of the University of Michigan's observatory at Ann Arbor, and there he began a tradition of accurate astronomical measurement which has deeply influenced American astronomy.

The continuity of Dunsink's history was broken in 1921, when the observatory ceased operations. But in 1947 the Irish government re-established the observatory. Since then, under the directorship of Dr. H. A. Brück, it has been refitted with modern instruments, and has become a flourishing center of astronomical research.

Today the chief telescope at Dunsink Observatory is the new 28-inch Cassegrainian reflector, whose dome can be seen atop the roof of the main building in this month's front-cover picture. Largely built in the observatory shop, this instrument is especially intended for photoelectric photometry, and it is fitted with a modern pulse-counting photometer.

Studies of the sun form an important part of Dunsink's research program. In this work, the main instrument is the recently reconstructed solar telescope, which has an effective focal length of 55 feet. It is in the main building. Sunlight is fed by a 16-inch coelostat, mounted on the roof, into an off-axis 14-inch Cassegrainian reflector, and thence into a grating spectrograph. There is also a spectroheliscope, by which a 2-inch-diameter image of the sun can be scanned in light of a single spectral line.

(Continued on page 501)

The International Astronomical Union

Otto Struve

Leuschner Observatory
University of California

The third American to serve as IAU president, Dr. Otto Struve is director of the Leuschner Observatory at Berkeley, Calif. Moss photograph, courtesy California Academy of Sciences.

This is the text of an address by the President of the International Astronomical Union at the opening of its Ninth General Assembly in Dublin, August 29, 1955.

We have met in many different countries: Italy in 1922, England in 1925, Holland in 1928, the United States in 1932, France in 1935, Sweden in 1938, Switzerland in 1948, and again in Italy in 1952. Now we have come, for the first time, to the Republic of Ireland—and we are grateful to the Government, to the two great universities of Dublin, and to the Dunsink Observatory for having extended to us their hospitality. We have a larger attendance here than we have had at any previous meeting, and we look forward to a week of absorbing interest for all of us.

My own acquaintance with Ireland goes back only a little more than nine years. But I made that acquaintance in the service of the IAU. You will recall that soon after the end of the war Sir Harold Spencer Jones and Dr. J. H. Oort decided to hold a meeting of the executive committee in Copenhagen and invited a number of astronomers who were not members of the committee. And so, on a stormy morning in March, 1946, Harlow Shapley, Joel Stebbins, and I alighted at the Shannon airport from a transatlantic plane. Shannon was not then, as it is now, the daily meeting place of thousands of travelers. Yet, to our surprise, the waiting room was crowded with people. As we were waiting for the announcement that our flight was ready to proceed, Dr. Stebbins called my attention to a distinguished appearing gentleman who was sitting across the room. I saw a face that seemed strikingly familiar, yet I could not identify it. So we called an attendant and asked him. The boy seemed surprised and slightly impatient at our ignorance. "You don't know?" he said. "That is the one and only Dev!" To us Americans this was the finest demonstration of Irish democracy we could have had. Dr. Shapley, who is always interested in the international aspects of astronomy and who, at this particular time, was engaged in planning a joint observatory in Africa with the participation of Armagh, Dunsink, and Harvard, asked the boy whether he could speak with Mr. de Valera. "Of course," replied the boy, "in our country anyone speaks to the prime minister!"

Mr. de Valera was at the airport to receive the American cardinals who were returning home from a trip to the Vatican. Bad weather had delayed their plane, and it forced us to remain in Ireland for 24 hours. We spent the night in a small hotel, the Blue Boar, in Tipperary—a name known to me from the words of the popular song, "It's a long, long way to Tipperary."

Many in this audience are attending for the first time a meeting of the IAU. Few of those in attendance were present when the union was founded in Brussels in 1919—I know of only one: Prof. F. J. M. Stratton. I believe that only three, Prof. Giorgio Abetti, of Italy, Prof. Shapley, of the United States, and Prof. Stratton, of Great Britain, have attended all general assemblies up to that in Rome three years ago. It may, therefore, be useful to review the aims of the union before we start our activities this afternoon.

The purpose of the union is stated in Article I of the statutes, as follows:

(i) to facilitate the relations between astronomers of different countries where international co-operation is necessary or useful;

(ii) to promote the study of astronomy in all its departments.

With these broad principles we are as much in accord today as were our founders 36 years ago. But from time to time there is a need to re-examine these cornerstones of our organization, and to seek new ways to implement them. It is the duty and the privilege of the president to give attention to these matters, and most of my predecessors have done so in one form or another. In his opening address to the union at its first meeting in Rome, in 1922, President Benjamin Baillaud interpreted the purpose of the union in these simple words:

"La recherche astronomique est l'objet essentiel de notre Union." And he added, "Ce sont toujours les plus grands instruments, disaient Paul et Prosper Henry qui ont donné les dernières découvertes en astronomie. La formule est peut-être un peu excessive. Cependant, un peu modifiée, elle devient: les plus grands instruments permettent de faire ce que ne permettent pas les autres. Il y a là une nouvelle révolution: après l'invention des lunettes, de la spectroscopie, de la photographie, voici venir les instruments géants, qui doivent être des chefs d'oeuvre de mécanique et d'optique, établis dans les sites les plus favorables à tous égards. . . . La vie de l'astronome continuera certes à être austère; mais combien n'est-elle pas séduisante par l'immensité des problèmes à résoudre et la certitude d'y récolter une riche moisson. Peu de sciences font autant d'honneur à l'humanité."

Three years later, at the University of Cambridge, W. W. Campbell returned

to this subject in the following words:

"Those of us who were privileged to take part in the organisation of the International Astronomical Union, at Brussels six years ago, will remember that unusual care was exercised in defining the purposes and function of the Union. It was not to be a society, international in scope, to provide the opportunity for the reading of papers describing work already done and results already obtained. Some of us recalled that several societies, more or less international in constitution, representing astronomy and other sciences, had long existed, and that they did not attract attendance from beyond the oceans in appreciable numbers. A study of the subject led us to the conclusion—a conclusion doubtless reached earlier by others—that national societies with principal functions the reading and discussion of papers relating to researches conducted by individuals meet a definite need, and in many cases are splendidly successful, but that societies international in character, to command attendance and success, must have other and broader aims, more general and more impelling purposes.

"It is to be noted, in article (I) [of the constitution], that the motive is 'international co-operation when *necessary* or *useful*.' The words *necessary* and *useful* have been chosen with care. The article does not say, international co-operation whenever *possible*, nor does it encourage a search for problems to the solution of which international co-operation could be applied. Whether we are looking for technical results of great value, or for the improvement of relations between the peoples concerned, international co-operation, to be justified, should have such impelling motives as to give clear promise of usefulness and success.

". . . experienced astronomers recalled the fact that the great advances in the several sciences have been the results of developments and discoveries made by individuals, and that this principle will always hold true; and, further, that the Union then in process of organisation should never be in a position to interfere with individual initiative. . . . The purposes of the Union refer to future developments, rather than to a recital of the accomplishments of the past."

Equally instructive are the following words of W. de Sitter, who presided at the Leiden meeting in 1928:

"Science is international by necessity and by choice, and astronomy, the oldest of the sciences, has perhaps more need of international co-operation than any other science, and also has always been in the front ranks of those who are seeking international organization. . . .

"Astronomy is a science that must be served for its own sake, or not at all. It is, one might say, a useless science, as it has no practical applications worth speaking of, and the little practical knowledge of astronomy, that is required for those few applications that it has, is easily acquired by anybody. As Poincaré has so beautifully expressed it: it is not science that is useful because its discoveries make technical progress possible, but technical progress is useful because it enables mankind, by relieving it of material cares, to give more time to science and to art. . . . I will . . . accept the extreme consequences of Poincaré's point of view and say that even by its utter uselessness astronomy is the most beneficial of all sciences for serving the ideal aims of mankind."

And, finally, I quote from Sir Frank Dyson's speech at the Harvard meeting of the union in 1932:

"We believe, as the Secretary of the Navy has said, that astronomy is very important for navigation and for the world. In astronomy, as in science generally, we are building on the work of our predecessors; and one never knows what will be discovered, perhaps something quite unexpected. Nothing has appealed to the popular imagination more than the Einstein discovery of relativity. There is much to learn, possibly something to correct. It is our business to follow Herschel's maxim—'Whatever shines must be observed'."

The highlights of these earlier interpretations of the activities of the union may be summarized as follows:

There was Baillaud's insistence upon the supreme importance of great telescopes.

There was Campbell's warning that we should engage only in those activities which really require international co-operation, and that we should never interfere with the individual initiative of great minds.

There was de Sitter's emphasis upon the fact that the apparent uselessness of astronomy renders it the most beneficial of all sciences in serving the ideal aims of mankind, and

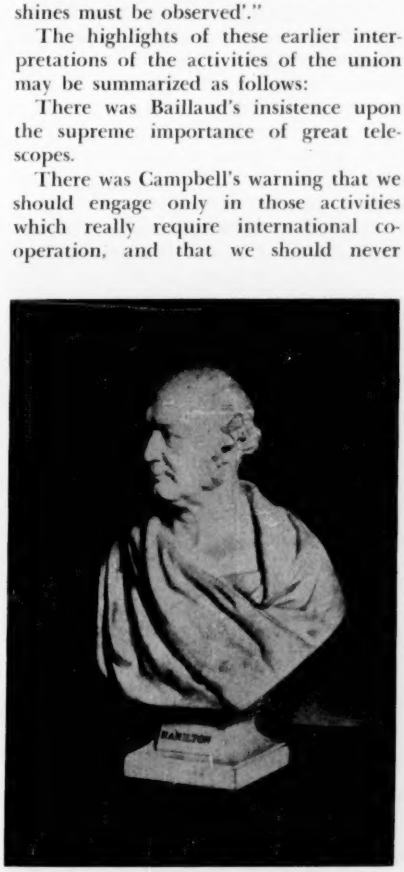
There was Dyson's quotation from Herschel that whatever shines must be observed.

If we are to re-interpret our function at the present time, we must, I believe, focus attention upon those changes that have taken place in astronomy, and in science in general, during the past few decades. This can be done in several ways, but I thought it would be most instructive to turn back the pages of history and to compare the achievements of our predecessors with those made by ourselves and our contemporaries. And while our time scale is an arbitrary one, based upon the accidental length of the period of the earth's orbital motion around the sun, let us ask ourselves: What was astronomy like one hundred years ago?

I find in a treatise on the history of science the following entry for the year 1853: "Lectures on Quaternions—As great an advance over analytical geometry as the latter was over Euclidean geometry." And who was the author of these lectures? Sir William Hamilton, whose bust graces the main room of the famous library of Trinity College in Dublin, and who in 1827, at the age of 22, was appointed to the position at the Dunsink Observatory that is now being filled by our host, Prof. H. A. Brück. Sir Robert Ball, also a director of this observatory, wrote in 1892: "The history of Dunsink Observatory for the next 38 years [after Hamilton's appointment at Dunsink Observatory] may be epitomised in a single word—Quaternions." Some of us may not have had occasion to use this remarkable extension of vector calculus, but no astronomer in this room has failed to study Hamilton's methods of dynamics!

William Rowan Hamilton was born on August 4, 1805, at No. 36 Dominick Street, Dublin. A remarkable child, at the age of three he could read English and make advanced arithmetical calculations. At 17 he visited John Brinkley at the observatory and discussed with him two papers, entitled "Osculating Parabola to Curves of Double Curvature and Surfaces" and "On Contacts between Algebraic Curves and Surfaces."

But Hamilton's great work on quaternions was not the only important advance of one hundred years ago. In 1854 Helmholtz, in Germany, announced his gravitational theory of the origin of solar energy. While we no longer believe that the contraction of the sun is responsible for its light and heat, this theory has become important again in recent years in our discussions of the early stages of stellar evolution. Also



Sir William Rowan Hamilton (1805-1865) became director of Dunsink Observatory and professor of astronomy at Dublin while he was still a 22-year-old undergraduate.

in the year 1854, Pogson, in England, standardized the ratio of the brightnesses of stars of different apparent magnitudes and thereby introduced into astronomy the ratio that bears his name. Two years later Steinheil, in Germany, and Foucault, in France, independently invented the silvering process for astronomical mirrors.

But I believe that if we are to choose a purely astronomical event of overwhelming importance, whose 100th anniversary we may rightly celebrate today, it is the monumental work of Argelander which culminated in the *Bonner Durchmusterung*. The year 1855 is probably better known to astronomers than any other: We have all been called upon to compute the precessions of the stars from the standard epoch of the Bonn zones!

Argelander wrote in the third volume of the *Astronomische Beobachtungen auf der Sternwarte zu Bonn* that the observations of more than 300,000 stars were started in 1852 with a Fraunhofer comet seeker three inches in aperture and 24 inches in focal length. The observations were continued by Argelander, Schoenfeld, and Krueger.

It is of interest to note that the IAU at the Zurich meeting in 1948 recommended that a new edition of the charts of the BD be produced by the Bonn Observatory. Dr. Friedrich Becker, the present director of the Bonn Observatory, is to be congratulated upon having carried out this important task.

A dominating figure in astronomy 100 years ago: Friedrich Argelander (1799-1875), director of Bonn Observatory. He was the father of variable star astronomy. A tireless observer and able organizer, he produced the "Bonner Durchmusterung," a catalogue and atlas of the northern sky, showing nearly all the stars visible in a 3-inch telescope. Today it is still a much used astronomical reference work.

These examples suffice to illustrate the tremendous change that has taken place in astronomy. One hundred years ago the most important advances were made by single men of genius, in this case by Hamilton and Helmholtz, working alone in the privacy of their "ivory towers," and by a few able observers (Argelander, Schoenfeld, and Krueger) using small telescopes at a single observatory. At the present time the emphasis is upon teamwork and upon the use of very large and expensive instruments at many observatories.

It is an intriguing question to decide whether this emphasis upon teamwork has deprived the world of individual thinkers like Hamilton and Helmholtz, but no one will deny that their numbers have not increased as rapidly as has the number of more-or-less anonymous scientific workers whose results now account for the major share of scientific production. We might well ask ourselves whether we are doing enough by following Campbell's advice of not interfering with individual initiative. Perhaps we should more actively encourage such initiative and accord it proper recognition in our union by providing for a kind of membership that does not require the pigeonhole of a commission. I remember several occasions in the past when an eminent astronomer could not become a member of the union because there was no suitable pigeonhole for him. Our only solution of the resulting dilemma was to create, artificially, a new commission in order to accommodate such a person.

Nevertheless, the great majority of our members are team workers, and for them the present structure of the union is reasonably satisfactory. We should recognize at once that we have already departed to a large extent from Campbell's idea that the union should be concerned with future developments and not with the recital of accomplishments of the past. We have found by experience that the symposia, which, in effect, do consist of such recitals, form a necessary basis upon which to build our plans for the future. At the same time, let us not lose sight of the fact that our principal purpose remains, as before, the planning of astronomy in all its aspects. This we are already doing at our meetings, but I believe we are doing it unconsciously rather than as the result of a well-directed effort. And I am afraid we are doing it on a timid and haphazard scale.

Let me read to you two excerpts from a study inspired in 1919 by George Ellery Hale. The first is by Elihu Root, a former board chairman, Carnegie Institution of Washington, a secretary of war and of state in the cabinet of Theodore Roosevelt, and a close associate of Woodrow Wilson in the Paris peace negotiations. He wrote:

"Science has been arranging, classifying, methodizing, simplifying everything except itself. It has made possible the tremendous modern development of the power of organization which has so multiplied the effective power of human effort as to make the differences from the past seem to be of kind rather than of degree. It has organized itself very imperfectly. Scientific men are only recently realizing that the principles which apply to success on a large scale in transportation and manufacture and general staff work apply to them; that the difference between a mob and an army does not depend upon occupation or purpose but upon human nature; that the effective power of a great number of scientific men may be increased by organization just as the effective power of a great number of laborers may be increased by military discipline."

The second quotation is from the writings of Henry S. Pritchett, formerly president of the Carnegie Foundation for the Advancement of Teaching:

"The world still conceives of scientific investigators in much the same light as the old time prospectors for the precious metals—each individual sinking his shaft here or there as chance or inclination may carry him. Of the great number so engaged a very few will strike veins of true gold, a larger number will obtain ore that will at least repay the labor and cost involved in their adventure, but the great majority will sink holes in barren and fruitless soil."

These are strong words, and they will arouse in many minds the thought of regimentation. Can we increase and improve our planning activities and at the same time stimulate the individual astronomer to bring out his best and original effort? Fortunately, the IAU possesses no powers of any kind. It can act only in an advisory capacity. Its funds are so limited that it cannot even bring the strength of money to bear upon the enforcement of its views. I am, therefore, not fearful of regimentation. The union could and should act as the supreme counseling center for all astronomers who request advice. It should also go beyond this and make specific recommendations through the various national committees to their respective governments, and it should formulate and constantly revise a general plan for developing astronomy in all its aspects.

How can this task be accomplished? As a believer in evolution rather than revolution, I do not advocate sudden changes. But it seems to me that the president, who has little to do between meetings, and the vice-presidents, who have even fewer assignments, could constitute themselves as an informal committee and prepare appropriate statements for presentation at our general assemblies. As a first step in this direction, I suggest:

That the national delegations represented at this meeting take home with them certain recommendations for consideration by their national committees and for possible presentation to their appropriate government agencies;

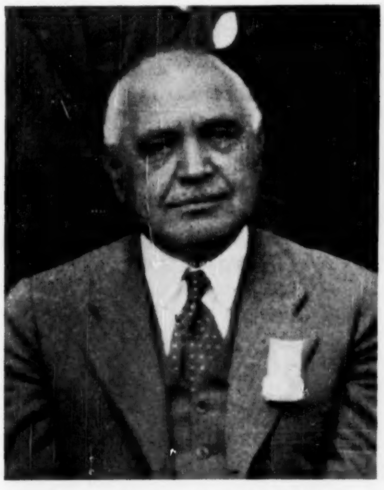
That these same recommendations be mailed to the national committees of those member countries that are not represented here;

That they be also communicated to such scientific organizations as national academies, research councils, professional societies or even government agencies in countries that do not claim membership in the union.

My recommendations are as follows:

1. Astronomy is international in character and requires the active participation of *all* civilized nations. The International Astronomical Union solicits the adherence of all countries that are interested in research. It now has a membership of 36 nations, and several new applications are pending at this meeting or are in the process of formulation.

2. Astronomy is also global in extent, and many of its most pressing problems can only be solved by means of observations distributed over the entire surface of the earth.



President of the IAU in 1935 was Frank Schlesinger, Yale University Observatory, shown here at the Paris meeting held in that year.

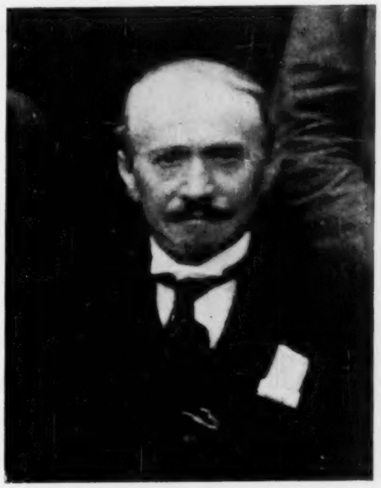
3. Astronomy is, as de Sitter has said, "the most beneficial of all sciences" because it uplifts the minds of all people and, more than any other science, serves "the ideal aims of mankind." Just before the outbreak of the second World War, in 1938, Sir Arthur Eddington remarked, in accepting the presidency of the union: ". . . if in international politics the sky seems heavy with clouds, such a meeting as this at Stockholm is as when the sun comes forth from behind the clouds. Here we have formed and renewed bands of friendship which will resist the forces of disruption."

The success of our union since the end of the war has shown that ideological and political differences fade away in our common goal, the exploration of the universe. Moreover, astronomy is no longer so "useless" as it was 27 years ago, largely because of the stimulus it has given to the study of nuclear energy. And in these days of serious consideration of future developments such as an artificial satellite of the earth, and even space travel, it promises to become one of the useful sciences in a practical sense.

4. There has been a disquieting increase in the disparity of astronomical effort in different countries. One hundred years ago some of the most important advances were made in small and poor countries. Today this is rarely the case. Those countries which were greatly disturbed by the recent wars have of necessity come to appreciate to a greater extent the importance of basic science than have those countries that experienced lesser upheavals. The support of basic science is a small item in any national budget. Perhaps, it should be kept at a reasonable level in order to provide for the necessary uniformity of geographical distribution of astronomical research. In the United States the annual expenditure on astronomy between 1923 and 1948 was of the order of $1,500,000 per year. At the present time this figure should be more than doubled. The National Science Foundation spends about $200,000 annually for small research projects by individual investigators. It plans to spend several million dollars a year for larger enterprises such as a new national observatory, several large radio telescopes, and several large electronic computing centers.

5. The most important tools of astronomy are the astronomers. Their training should be the first concern of all countries. To a small extent the IAU has helped—and is ready to help—in this task through its commission on the exchange of astronomers, under Prof. Stratton. A special effort should be made to induce persons of great ability to enter the field of astronomy, and individual workers of the "ivory-tower" variety should be encouraged. Countries that have not yet developed astronomical research to any great extent can avoid many of the difficult steps by providing opportunities for their citizens to study in large institutions abroad. Most national governments encourage foreigners to visit their institutions and give them opportunities to profit from the experience of existing organizations.

6. The importance of large telescopes, already stressed by Baillaud in 1922, has still further increased. There is urgent need for a greatly increased flow of basic information. Any astronomer can think of dozens of programs of observation—for example, the continuous spectroscopic and photometric survey of rapidly evolving binary stars like Beta Lyrae—that cannot now be carried on with existing telescopes. We may safely assume that the flow of recorded facts needs to be increased by a factor of 10, and the number of large telescopes by a corresponding factor, if we are to provide the information that is required for theoretical studies. No one needs to fear that the 200-inch Hale reflector will solve all remaining problems.



E. Esclangon, then director of the Paris Observatory, presided at the IAU's 1938 meeting in Stockholm.

7. There must be diversity in the construction of telescopes. Countries that have poor climatic conditions might concentrate upon radio telescopes, while others with good daytime seeing might emphasize solar research.

The executive committee of the IAU stands ready at any time to furnish advice on these subjects.

IMPROVED LUNAR EPHEMERIS

E. W. Brown's famous *Tables of the Motion of the Moon,* in use since 1923, are no longer sufficiently precise to predict the moon's position for all modern needs. However, these tables do not give the full accuracy of Brown's formulas, for many short cuts and approximations were made so that the tables would be easier to use. It was demonstrated in 1948 that modern electronic computing machines could calculate the moon's position directly from the formulas, bypassing Brown's tables. Starting with 1960, all national ephemerides of the moon will be given to 0.001 second in right ascension and 0".01 in declination, and will be computed directly from the formulas. To bridge the interval until 1960, the American and British nautical almanac offices have jointly prepared an extensive volume, *Improved Lunar Ephemeris, 1952-1959.* This provides the moon's latitude, longitude, and parallax at half-day intervals, and its right ascension and declination for every hour.

A Model of the Solar Neighborhood

A. E. Whitford and J. W. Slowey
Washburn Observatory, University of Wisconsin

A MODEL showing the size, color, and location in space of stars known to be within five parsecs of the sun has recently been constructed at the University of Wisconsin, as a laboratory exercise by students in the elementary astronomy course. The idea of such a model is not new, but use of modern "black-light" technique makes such an exercise dramatic as well as instructive. And it was found that the students benefited fully as much from constructing the model as they did from studying it when completed. Calculating the quantities needed for mounting each star uses quite a number of the basic concepts of stellar astronomy.

For example, placing a star in the model involves specifying its direction from the sun in celestial co-ordinates, and finding the distance of the star from its parallax. Also, before the diameter of the star is determined, its luminosity in solar units must be found, thus giving a review of absolute magnitude calculations. It is forcibly impressed on the modelmaker how temperature and surface area enter in determining the luminosity of a star.

The Wisconsin students started with a prepared table giving the name, right ascension and declination, the parallax, apparent visual magnitude, and the spectral class for each star known to be closer than five parsecs. These data are given by Dr. P. van de Kamp's table on page 498-9 of this issue. The table lists several stars that are sure to be familiar, such as Alpha Centauri, Sirius, Procyon, and Altair. The majority, however, are faint and have unfamiliar designations, such as Wolf 359 and Groombridge 34.

Each pair of workers was given the task of mounting two or three stars on the model. First the diameter of each star is calculated from the relation,

$$d = (L/B)^{1/2},$$

where d is the diameter, L the luminosity, and B the surface brightness (visual light per unit area), all expressed in solar units. The luminosity can be taken directly from Dr. van de Kamp's list, and a table of the surface brightness B for each spectral type is given here.*

Surface Brightness of Stars Relative to the Sun

Type	*B*	*Type*	*B*	*Type*	*B*
*B*0	32.4	*F*5	1.91	d*M*0	0.043
*B*5	17.8	d*G*0	1.02	d*M*2	0.039
*A*0	9.8	d*G*5	0.74	d*M*4	0.0354
*A*5	5.5	d*K*0	0.44	d*M*6	0.0170
*F*0	3.23	d*K*5	0.117	d*M*8	0.0135

To represent the sizes of the stars, a convenient scale is obtained by using a one-centimeter sphere for the sun. The student selects a bead of the proper diameter and dips it in fluorescent lacquer of a color determined by the spectral type. An appropriate set of colors was found to be: for *A* stars, white; *F*, light yellow; *G*, yellow; *K*, orange; *M*, red. Fluorescent lacquers are obtainable in most large cities; outdoor advertising firms and theatrical supply houses are possible sources.

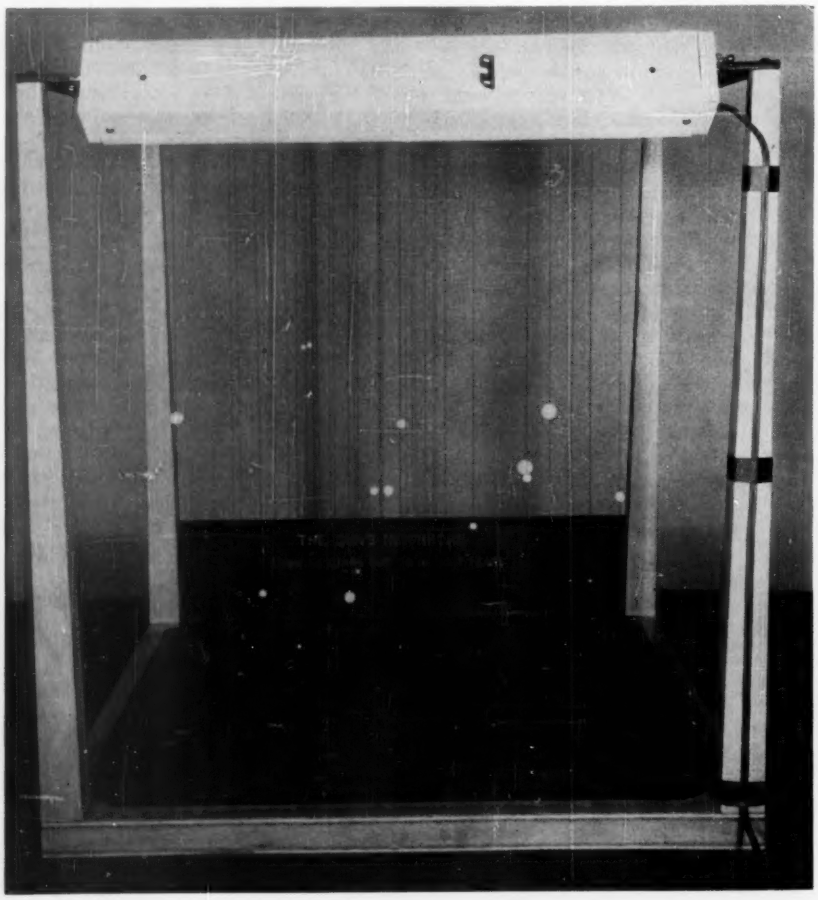
For most of the stars, a string of "pearls" from the 5-and-10-cent store has a sufficient range in size. The largest stars, such as Sirius A and Procyon A, are hardwood beads turned out on a lathe. The smallest dwarfs require very fine beads as used in Indian beadwork.

While the lacquer is drying, one may calculate the location of the star in the model. Since the stars are suspended on vertical black threads, it is natural to compute the projected co-ordinates in the equatorial plane, and the height above or below that plane. If D is the distance of the star, δ the star's declination, r the projected distance on the equatorial plane, and h the vertical distance from the equatorial plane, then

$$r = D \cos \delta,$$
$$h = D \sin \delta.$$

It is convenient to use a scale of distances where five centimeters equal one parsec (corresponding to 1.53 centimeters per light-year). The supporting frame will then need to be about two feet square. A polar co-ordinate grid marked in right ascension and parsecs (or light-years) is pasted to both the upper and lower decks of the frame; the equatorial plane is midway between them.

Starting with the sun at the center, the stars are then hung in place on taut threads. A vertical ruler showing parsecs (or light-years) above and below the horizontal plane is helpful in adjusting the height. The upper end of the thread is secured with Scotch tape and the lower with a stapler.

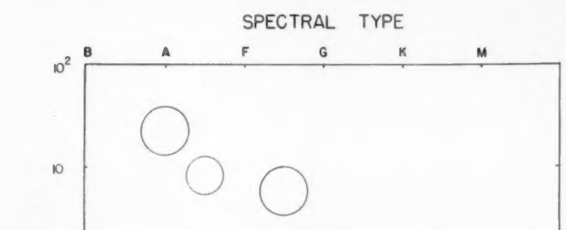


To illuminate the model, a 15-watt tubular fluorescent lamp is obtainable with a built-in black-light filter. It gives excellent diffuse illumination. The technical designation is F15T8/BLB, and it can be ordered from any dealer in fluorescent lighting equipment.

When the room lights go out and the black light is turned on, there is always a murmur of surprise and delight. The threads disappear and the stars, now showing brilliant colors, seem to be floating in space. The student has before him a sample of a stellar population. It contains no giants, and only four stars intrinsically brighter than the sun. The majority of the stars are faint red dwarfs, whose actual preponderance is graphically presented. The considerable fraction of double and triple star systems is also impressive. The thinning out of the stars in the outermost part of the model indicates our incomplete knowledge of even the nearby stars.

In one respect the model gives a distorted view, since it is necessary to choose different scales for distances and diameters. Consider what would happen if Arcturus chanced to be within the five-parsec limit. Its diameter in the model would be about a foot, and a good number of the other stars would be engulfed by it. The wide disparity of scales is unavoidable; if the scale adopted for the diameters had been used for the distances, stars on opposite sides of the model would have been 1,300 miles apart.

Above: This black-light view of the model shows the nearby stars apparently suspended in space. The sun is at the center, with the double star Alpha Centauri just below; Altair is at the far left. Sirius and Procyon are the largest stars on the right. The model is viewed from the direction right ascension 0 hours, declination +15°.



Left: The spectrum-luminosity relation for the stars closer than five parsecs. Sizes of the circles indicate the relative diameters of the stars. The recently detected star of smallest known mass, Ross 614B, could not be plotted, as its spectral type is unknown. Diagram, courtesy Dr. Peter van de Kamp, from the data on pages 498-9.

Our students have been quite spontaneous in their enthusiasm, and have expressed the feeling that constructing the model has been one of their more rewarding exercises. It can be constructed in a three-hour laboratory session, but this may require that some of the data be precalculated.

The completed model makes an eye-catching demonstration on public nights. The photographically inclined may attempt color shots, or even stereoscopic pictures.

*For any stars, the values needed to construct a model such as this may be derived from the parallaxes, apparent magnitudes, and spectral classes.

The parallax, p, is expressed in seconds of arc; its reciprocal, $1/p$, is the distance, D, in parsecs. (One parsec equals 3.26 light-years.) The absolute magnitude, M, is found from the equation,

$$M = m + 5 - 5 \log D,$$

where m is the apparent magnitude. The star's luminosity, in terms of the sun as unity, is then derived from the equation,

$$\log L = 0.4\ (4.7 - M),$$

where 4.7 is the absolute visual magnitude of the sun.

The table of stellar surface brightness given in the article is based on the formula,

$$\log B = 2.03 - 11{,}700/T,$$

which may be derived from arguments like those on page 732 of Russell, Dugan and Stewart's *Astronomy*. Here T is the surface temperature of the star in degrees absolute.

STARS NEARER THAN FIVE PARSECS

Peter van de Kamp, *Sproul Observatory, Swarthmore College*

Among the many different kinds of stars, astronomers want to know which are most numerous and which are most sparsely distributed. The naked-eye stars as a group cannot be used, because they do not make up a typical sample of the stellar population. A listing of naked-eye stars is overweighted in favor of very luminous objects which are conspicuous at great distances, and there are too few of the intrinsically very faint dwarf stars, for the latter can be discovered only if they are nearby.

Therefore, to find which kinds of stars actually are most numerous, it is best to make a stellar census within a relatively small volume around the sun. The list given here is of all known stars within five parsecs—16 light-years—of the sun; it includes stars with parallaxes greater than 0.195 second of arc. The distance limit is arbitrary; it is chosen because it gives a sufficiently large and reasonably complete sample of stars.

The table is reproduced, by permission, from the author's article of the above title in the April, 1953, issue of the *Publications* of the Astronomical Society of the Pacific. Only one significant change has become necessary since that time, because the hitherto unseen component of Ross 614 has been observed with the 200-inch telescope (see page 364, July issue). Four other stars, indicated in the table by asterisks, undergo perturbations that indicate the presence of unseen companions.

Among these nearby stars, two facts stand out. The majority are faint; less than a dozen are visible to the naked eye. Double stars are common. Of the 42 entries in the table, 30 are single stars, 10 are double star systems, and two are triple systems, leaving unseen companions out of consideration. If these were included, 60 stars would be involved, and only 27 appear at present to be isolated individuals.

Thirty-six stars are of spectral type *M*, which would indicate that the great majority of stars in our part of the Milky Way are intrinsically very faint red dwarfs. The list also contains five white dwarfs: van Maanen's star, CC 658, and the companions of Sirius, Procyon, and o^2 Eridani.

The reader may be familiar with most of the column headings. The *proper motion* of each star is its apparent change of position in the sky, expressed in seconds of arc per year. Because all these stars are near to us, they have large proper motions, the smallest being half a second of arc per year. The *cross motion* is the star's velocity perpendicular to the line of sight, expressed in kilometers per second; cross motion can be obtained from the proper motion by taking the star's distance into account. The *position angle* of the proper motion (and the cross motion) is the direction toward which the star appears to move on the celestial sphere; it is counted from

No.	Name	R.A. 1950	Decl. 1950	Parallax	Distance in Light-Years	Proper Motion	Cross Motion km/sec	Position Angle
1	Sun	— —	— —	—	—	—	—	—
2	α Centauri	$14^h\ 36^m.2$	−60° 38′	0″.760	4.3	3″.68	23	281°
3	Barnard's star	17 55.4	+ 4 33	0.545	6.0	10.30	90	356
4	Wolf 359	10 54.2	+ 7 20	0.421	7.7	4.84	54	235
5	Luyten 726-8	1 36.4	−18 13	0.410	7.9	3.35	38	80
6	Lalande 21185	11 0.6	+36 18	0.398	8.2	4.78	57	187
7	Sirius	6 42.9	−16 39	0.375	8.7	1.32	16	204
8	Ross 154	18 46.7	−23 53	0.351	9.3	0.67	9	106
9	Ross 248	23 39.4	+43 55	0.316	10.3	1.58	23	176
10	ε Eridani	3 30.6	− 9 38	0.303	10.8	0.97	15	271
11	Ross 128	11 45.1	+ 1 7	0.298	10.9	1.40	22	151
12	61 Cygni	21 4.7	+38 30	0.293	11.1	5.22	84	52
13	Luyten 789-6	22 35.7	−15 37	0.292	11.2	3.27	53	46
14	Procyon	7 36.7	+ 5 21	0.288	11.3	1.25	20	214
15	ε Indi	21 59.6	−57 0	0.285	11.4	4.67	77	123
16	Σ 2398	18 42.2	+59 33	0.280	11.6	2.29	38	324
17	Groombridge 34	0 15.5	+43 44	0.278	11.7	2.91	49	82
18	τ Ceti	1 41.7	−16 12	0.275	11.8	1.92	33	297
19	Lacaille 9352	23 2.6	−36 9	0.273	11.9	6.87	118	79
20	BD +5° 1668	7 24.7	+ 5 29	0.263	12.4	3.73	67	171
21	Lacaille 8760	21 14.3	−39 4	0.255	12.8	3.46	64	250
22	Kapteyn's star	5 9.7	−45 0	0.251	13.0	8.79	166	131
23	Kruger 60	22 26.3	+57 27	0.249	13.1	0.87	16	247
24	Ross 614	6 26.8	− 2 47	0.248	13.1	0.97	18	131
25	BD −12° 4523	16 27.5	−12 32	0.244	13.4	1.24	24	180
26	van Maanen's star	0 46.5	+ 5 10	0.236	13.8	2.98	59	155
27	Wolf 424	12 30.9	+ 9 18	0.223	14.6	1.87	40	278
28	Groombridge 1618	10 8.3	+49 42	0.222	14.7	1.45	31	249
29	CD −37° 15492	0 2.5	−37 36	0.219	14.9	6.09	132	112
30	CD −46° 11540	17 24.9	−46 51	0.213	15.3	1.15	25	138
31	BD +20° 2465	10 16.9	+20 7	0.211	15.4	0.49	11	264
32	CD −44° 11909	17 33.5	−44 16	0.209	15.6	1.14	26	218
33	CD −49° 13515	21 30.2	−49 13	0.209	15.6	0.78	18	184
34	AOe 17415-6	17 36.7	+68 23	0.206	15.8	1.31	30	196
35	Ross 780	22 50.5	−14 31	0.206	15.8	1.12	26	120
36	Lalande 25372	13 43.2	+15 10	0.205	15.9	2.30	53	129
37	CC 658	11 42.7	−64 33	0.203	16.0	2.69	62	99
38	o^2 Eridani	4 13.0	− 7 44	0.200	16.3	4.08	96	213
39	70 Ophiuchi	18 2.9	+ 2 31	0.199	16.4	1.13	27	167
40	Altair	19 48.3	+ 8 44	0.198	16.5	0.66	16	54
41	BD +43° 4305	22 44.7	+44 5	0.198	16.5	0.84	20	237
42	AC 79° 3888	11 44.3	+78 57	0.196	16.6	0.87	21	57

From the *Publications* of the Astronomical Society of the Pacific.

north (0°) through east (90°) and so on. The star's *radial velocity* is its line-of-sight motion and is expressed directly in kilometers per second, positive for recession and negative for approach. Cross motion and radial velocity are right-angle components of the star's space motion relative to the sun.

Following the usual astronomical convention, the letters A, B, and C, used here as column headings, refer to the components of a double or multiple star. The *absolute magnitude* of a star is the apparent magnitude it would have if it were viewed from a standard distance of 10 parsecs (32.6 light-years); it is a convenient way of expressing the intrinsic brightnesses of the stars. The values in the table are based on a visual absolute magnitude of +4.7 for the sun. The *luminosity* of a star is its intrinsic brightness in terms of the sun's as unity. Only three stars in this list outshine the sun: Sirius, Altair, and Procyon. The faintest star in the list is Wolf 359, but Ross 614B is probably even fainter. The faintest star known is of absolute magnitude +19.3, but it is too far away—19 light-years—to be included here.

A convenient way of summarizing the properties of these nearby stars is in a diagram, like that on page 497, where each star is plotted with its spectral type and luminosity as co-ordinates. The sequence of stellar spectra is at the same time a sequence of surface temperature and color, as indicated on the diagram. The smallness of the fainter, cooler stars of the main sequence is shown by their plotted sizes. The five white dwarfs are also very small. There are no giant or supergiant stars in this sample.

Radial velocity km/sec	Visual Magnitude and Spectrum			Visual Absolute Magnitude			Visual Luminosity ☉			No.
	A	B	C	A	B	C	A	B	C	
0	−26.9 G0	—	—	4.7	—	—	1.0	—	—	1
− 25	0.3 G0	1 7 K5	11 M5e	4.7	6.1	15.4	1.0	0.28	0.000052	2
−108	9.5 M5	*	—	13.2	*	—	.00040	*	—	3
+ 13	13.5 M6e	—	—	16.6	—	—	.000017	—	—	4
+ 29	12.5 M6e	13.0 M6e	—	15.6	16.1	—	.00004	.00003	—	5
− 86	7.5 M2	*	—	10.5	*	—	.0048	*	—	6
− 8	−1.6 A0	7.1 wd	—	1.3	10.0	—	23.	.008	—	7
− 4	10.6 M5e	—	—	13.3	—	—	.00036	—	—	8
− 81	12.2 M6e	—	—	14.7	—	—	.00010	—	—	9
+ 15	3.8 K2	—	—	6.2	—	—	.25	—	—	10
− 13	11.1 M5	—	—	13.5	—	—	.00030	—	—	11
− 64	5.6 K6	6.3 M0	*	7.9	8.6	*	.052	.028	*	12
− 60	12.2 M6	—	—	14.5	—	—	.00012	—	—	13
− 3	0.5 F5	10.8 wd	—	2.8	13.1	—	5.8	.00044	—	14
− 40	4.7 K5	—	—	7.0	—	—	.12	—	—	15
+ 1	8.9 M4	9.7 M4	—	11.1	11.9	—	.0028	.0013	—	16
+ 14	8.1 M2e	10.9 M4e	—	10.3	13.1	—	.0058	.00044	—	17
− 16	3.6 G4	—	—	5.8	—	—	.36	—	—	18
+ 10	7.2 M2	—	—	9.4	—	—	.013	—	—	19
+ 26	10.1 M4	—	—	12.2	—	—	.0010	—	—	20
+ 23	6.6 M1	—	—	8.6	—	—	.028	—	—	21
+242	9.2 M0	—	—	11.2	—	—	.0025	—	—	22
− 24	9.9 M4	11.4 M5e	—	11.9	13.4	—	.0013	.00033	—	23
+ 24	10.9 M5e	*	—	12.9	*	—	.00052	*	—	24
− 13	10.0 M5	—	—	11.9	—	—	.0013	—	—	25
+ 26	12.3 wdF	—	—	14.2	—	—	.00016	—	—	26
− 5	12.6 M6e	12.6 M6e	—	14.3	14.3	—	.00014	.00014	—	27
− 27	6.8 K5	—	—	8.5	—	—	.030	—	—	28
+ 24	8.6 M3	—	—	10.3	—	—	.0058	—	—	29
—	9.7 M4	—	—	11.3	—	—	.0023	—	—	30
+ 10	9.5 M4e	*	—	11.1	*	—	.0028	*	—	31
—	11.2 M5	—	—	12.8	—	—	.00058	—	—	32
—	9 M3	—	—	10.6	—	—	.0044	—	—	33
− 17	9.1 M3	—	—	10.7	—	—	.0040	—	—	34
+ 9	10.2 M5	—	—	11.8	—	—	.0014	—	—	35
+ 15	8.6 M2	—	—	10.2	—	—	.0063	—	—	36
—	11 wd	—	—	12.5	—	—	.0008	—	—	37
− 42	4.5 K0	9.2 wdA	11.0 M5e	6.0	10.7	12.5	.30	.0040	.0008	38
− 7	4.2 K1	5.9 K5	—	5.7	7.4	—	.40	.083	—	39
− 26	0.9 A5	—	—	2.4	—	—	8.3	—	—	40
− 2	10.2 M5e	—	—	11.7	—	—	.0016	—	—	41
−119	11.0 M4	—	—	12.5	—	—	.0008	—	—	42

*Indicates unseen companion.

ARTIFICIAL SATELLITE IN 1957-58

American scientists will launch one or more small artificial satellites as part of the United States contribution to the International Geophysical Year, it was announced from the White House on July 29th.

Engineers had already agreed on the feasibility of the project, which has now been given active government support. The sum of $10,000,000 has been made available to the National Science Foundation for the task.

Despite much speculation, the detailed specifications of the first satellite have not yet been decided. One of several possibilities is the Mouse proposed by Prof. S. F. Singer, and described on page 15 of the November, 1954, *Sky and Telescope*. It is definitely planned to put the satellite into an orbit 200 or 300 miles above the earth's surface, and give it a velocity of about 18,000 miles per hour; it would then circle the earth once every 90 minutes. Even at that height the satellite will meet some air resistance and eventually spiral back toward earth. This may take from a few hours to a few weeks. When the "bird" descends into the relatively denser stratosphere, it will burn up, much like a meteor.

Even if the first satellite did not carry scientific instruments, tracking it by ground observations would give useful results. Its deceleration and the form of its spiral path should give better data on the density of the upper atmosphere.

Subsequent satellites, at least, are expected to carry equipment for studying solar radiation, cosmic rays, cloud coverage over the earth as a whole, and the transmission of radio waves through the ionosphere. Such data can be telemetered down to stations on the earth's surface. The information acquired from the satellites will be available to all of the more than 40 nations participating in the International Geophysical Year (July, 1957, to December, 1958).

American military organizations are involved in this project only to the extent of responsibility for getting the satellites properly launched in their orbits. Previous proposals have considered carrying up an artificial satellite by a three-stage rocket, or by a rocket launched from a high-altitude balloon or aircraft.

MORGAN CILLEY DIES

The passing of Reverend Morgan Cilley in Washington, D. C., at the age of 77 has removed an outstanding American amateur astronomer. For many years he had been an active member of the American Association of Variable Star Observers, to which he contributed more than 20,000 brightness observations of variables. Mr. Cilley had been a civil engineer and later a clergyman, and during World War II he was a staff member of the U. S. Naval Observatory.

These three domes at the Crimean Astrophysical Observatory, from left to right, house the 50-inch reflecting telescope, the 16-inch photographic refractor, and the 20-inch Maksutov-type telescope.

Crimean Astrophysical Observatory

A. B. SEVERNY, *Crimean Astrophysical Observatory*

AN OBSERVATORY belonging to an amateur astronomer served as the basis for the southern branch of the Poulkovo Observatory, set up in 1908 near Simeis in the southern Crimea at a height of 1,200 feet. The first astronomer in charge of the station was A. P. Gansky, a well-known investigator of the sun. During World War II, the observatory was heavily damaged by the forces of occupation, and its 40-inch reflecting telescope was destroyed.

After the war, it was decided not only to restore the observatory at Simeis, but to find another site where the seeing conditions would be better for spectrographic work. Today a new observatory has been built near the village of Partizanskoye, 2,100 feet above sea level, in the central part of the Crimean peninsula.

The new station has a 50-inch reflecting telescope with two spectrographs, a 20-inch Maksutov telescope with a coude focus, equipped for photoelectric registration of stellar spectra and colors, and a double 16-inch astrograph with an objective prism. In 1954 a solar tower telescope was set up, which uses a coelostat mirror 27½ inches in diameter and a 16-inch concave primary mirror. The tower telescope has a spectrograph and a photometer for recording the solar spectrum photoelectrically, and it can be used to take motion pictures of the sun in the light of a single spectrum line, as is done at the McMath-Hulbert Observatory in the United States. There is also a coronagraph of the Lyot type, with several narrow-band filters, including one for the infrared helium line at 10,830 angstroms.

At the rebuilt Simeis station, there is a 25-inch coma-free telescope, a nebular spectrograph, a 12-inch horizontal solar telescope with a Hale spectrohelioscope, and two cameras with which minor planets are regularly being photographed. There are several radio telescopes working at meter wave lengths. Sixteen astronomers and several radio engineers work here.

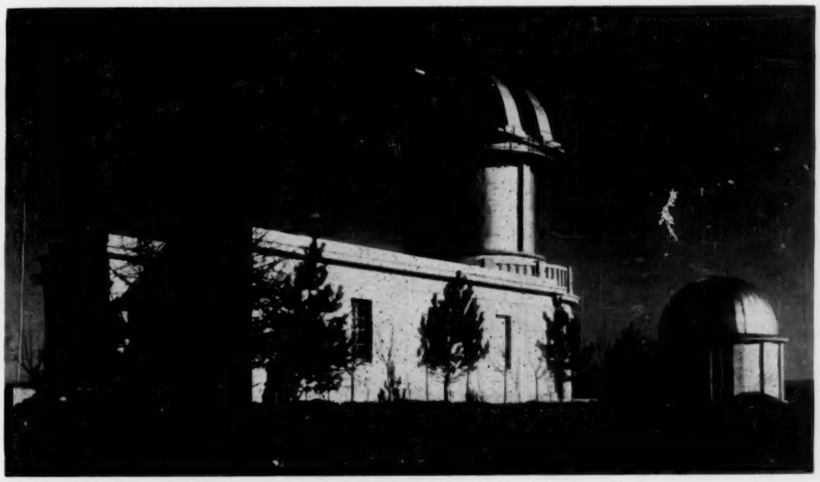
At both observatories, the work in stellar spectroscopy includes spectral classification of faint stars and the areas of stellar associations, and nebulae are being studied with narrow-band filters and the nebular spectrograph. Motion pictures are regularly taken of the sun in hydrogen-alpha light, and spectroheliograms are obtained in light from the H and K lines of ionized calcium. Solar radio emission is being regularly observed on a wave length of 1.5 meters, and observations of the magnetic fields of sunspots have begun.

In 1951, an electronic image converter was used to obtain photographs of the galactic center in infrared. A statistical study of novae by Kopylov has led him to conclude that these stars are not genetically related to the other types of explosive variables (novalike stars, recurrent novae, supernovae) nor with other types of hot stars.

Shajn and Hase have discovered a large number of new hydrogen emission nebulae. Many of these consist of nearly parallel filaments, as shown in photographs on pages 12 and 13 of *Sky and Telescope*, November, 1954. To explain these very elongated nebulae, the hypothesis has been advanced that there is an interstellar magnetic field which controls the distribution and perhaps the motion of diffuse matter in our galaxy.

Crimean investigations of large emission nebulae stress their internal motions and, in particular, the outward motions. The conclusions appear probable that nebulae in their emission stage have short lifetimes, of the order of one to 10 million years, and that they have a strong tendency to disintegrate. Observations of the brightnesses of the most conspicuous emission nebulae in M33, M101, and other galaxies, have led to an estimation of the masses of these nebulae as some thousands or tens of thousands of solar masses.

The writer and his associates have paid particular attention to solar studies. One investigation was the detailed examination of the spectra of 50 flares. One flare seems to appear, on the average, for every seven hours of the lifetime of a sunspot group. Photoelectric observations of the sun's spectrum have indicated the presence of deuterium on the sun, and Dubov has determined the solar lithium abundance to be half that found by Greenstein. Another project has been a photoelectric remeasurement of the brightness of the sun.



The solar tower telescope at the new Crimean station in southern Russia.

ASTRONOMICAL SCRAPBOOK

The Comets of the Chevalier D'Angos

THE FIRST TIME I ever heard of Jean August d'Angos was in Admiral Smyth's *Celestial Cycle* (1844). There you may read, in the account of the star cluster M92 in Puppis: "The unlucky Chevalier d'Angos, of the Grand-Master's observatory at the summit of the palace at Malta, mistook this cluster for a comet: from which, and some still more suspicious assertions, my excellent friend, Baron von Zach, was induced to term any egregious astronomical blunders—Angosiades."

Smyth was kind to the chevalier to call him merely a blunderer. J. F. Encke described another of his feats more outspokenly: "D'Angos had the audacity to forge observations that he never made, of a comet that he had never seen, based on an orbit he had gratuitously invented, all to give himself the glory of having discovered a comet."

D'Angos was a Frenchman, born at Tarbes in the Pyrenees on May 13, 1744. His career was varied, for besides being known as an astronomer and physician, he also served as a captain in the Navarre regiment of the pre-Revolutionary French army and became a Knight of Malta. (This was the original knightly order, and not its present-day namesake.) By 1780 he was well enough known to be named a correspondent of the French Academy of Sciences, and was elected an associate in 1796.

The grand master of the Knights of Malta invited d'Angos to the island and built an observatory with fine instruments for him in 1783. Here the chevalier dabbled in chemistry as well as astronomy, and a mishap with some phosphorus burned the observatory and its records in 1789. Soon after, d'Angos returned to France, and finally died at Tarbes on September 23, 1833.

The pretended comet of which Encke speaks is Comet 1784 II. On May 14th, Messier at Paris received a letter from the chevalier, dated April 15th, announcing the discovery four days earlier of a faint comet in Vulpecula, and giving two positions of it. Some time later a second letter reported its orbital elements. Messier was never able to find the comet, despite careful search, and no other astronomer reported observations of it.

Suspicion became attached to this comet in 1806, when the Paris astronomer, J. K. Burckhardt, wanted to recalculate its orbit. For this he needed three observations of its position, but Messier had received only two. A letter to d'Angos brought the reply that his records had all been lost except for a meteorological journal, which for April 22, 1784, mentioned only an observation of the zodiacal light; he was sure the comet must have ceased to be visible by then. Burckhardt, a tireless computer, thereupon took the two observations, and making various assumptions as to the comet's distance from the earth, calculated several sets of elements. None bore the slightest resemblance to the orbital elements that d'Angos had sent to Messier.

About a dozen years later, matters came to a head with the discovery that an obscure German periodical of 1786 contained a note by d'Angos, giving 14 observations of his comet, extending to May 1st. This contradicted what d'Angos had told Burckhardt, and moreover the newly found observations could not be represented by the chevalier's orbit. The suggestion of fraud was now stronger, and Encke finally uncovered the true story in 1820. He found that with d'Angos' elements he could reproduce the 14 positions, provided that in the calculations he used *exactly 10 times too large* a value for the earth's distance from the sun.

The conclusion was unmistakable that the chevalier had fabricated his observations of the comet, making this numerical error in the process.

But this is not an end to the impostures of d'Angos. In 1798 he wrote to the astronomers of Paris, saying that he had seen a comet cross the sun's disk on January 18th of that year. On this date the sun was at the descending node of the comet of 1672, according to its value in J. J. Lalande's *Astronomie*. Since d'Angos claimed that he had also seen a comet transit the sun in 1784, he asserted that both objects were returns of the comet of 1672, as the three dates were exactly fitted by a 14-year period. The defect fatal to the picture was promptly pointed out by the Dresden astronomer, J. G. Koehler: The value of the node of the comet of 1672 given in Lalande's *Astronomie* was a misprint, being 60 degrees in error. This comet could not possibly have passed in front of the sun in January, 1798, as claimed. Lalande, on learning of the imposture, denounced d'Angos in words that even the strong-minded Baron von Zach could not bring himself to repeat.

It is fortunate for astronomy that the career of the Chevalier d'Angos appears to be nearly unique. J. A.

DUNSINK OBSERVATORY—THEN AND NOW

(Continued from page 491)

Since 1950, the observatory has had its own access to the southern sky, through a share in the use of the Baker-Schmidt telescope of the Boyden station at Bloemfontein, South Africa. Recently an Eichner iris photometer has been installed at Dunsink, for the measurement of star magnitudes from photographs taken with the southern telescope. This summer it was announced that Dunsink is one of the six observatories that will jointly operate the Boyden station (see page 359 of the July, 1955, issue).

Thus Dunsink Observatory, now almost two centuries old, is entering a new era of vigorous activity.

Amateur Astronomers

A PUBLIC PLANETARIUM FOR ST. LOUIS

ONE MILLION DOLLARS for a major planetarium were recently included in a bond issue voted on by the citizens of St. Louis, Mo., with a favorable result, 106,000 for and 34,000 against. It will be the first planetarium in the country to be built at public expense and by vote of the people.

Some time ago, Howard C. Ohlendorf, chairman of the membership committee of the St. Louis Academy of Science, invited other cultural groups to discuss the idea of a science center for the city. After a number of meetings, representatives of seven amateur science organizations decided to concentrate on a planetarium as the first unit of such a center, and a Planetarium Forming Group was made up with Mr. Ohlendorf as chairman.

The seven societies sponsoring this effort are the St. Louis Amateur Astronomical Society, Audubon Society, and Meteorology Society, the Amateur Aquarius of Greater St. Louis, the Antique Automobile Club, the Archeological Society, and the Webster Groves Nature Study Club.

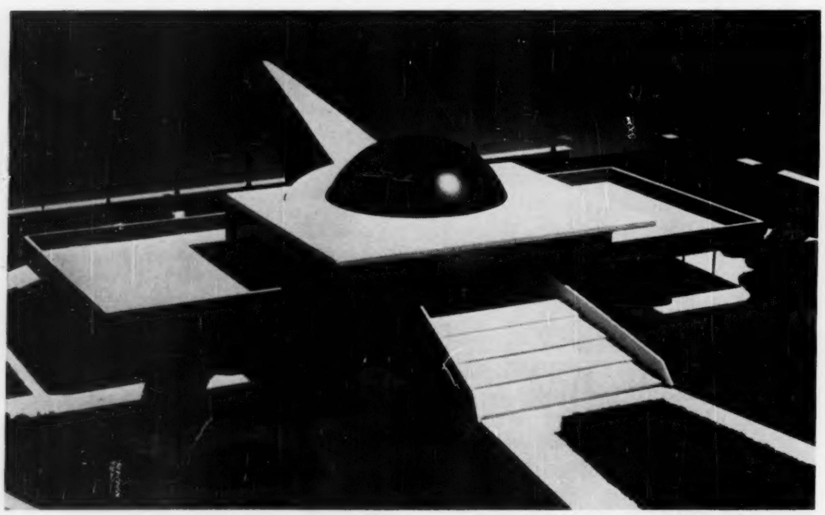
For presentation to the bond issue screening committee, the group assembled data on planetariums throughout the country, made estimates of costs and income, and had preliminary plans drawn for a chamber 50 to 60 feet in diameter, to seat up to 500 persons. They estimated the building to cost $550,000, the dome $50,000, and the projector $150,000; with other items, the total was $950,000.

After the project was accepted by the screening committee, the group, led by such well-known amateur astronomers as Michael Amantea, A. W. Callaway, E. Friton, Earl Hoffman, Owen McNammee, Stuart O'Byrne, and Donald D. Zahner, put on a concerted drive to arouse public interest. They gave several star parties, at two of which some 3,000 persons observed, but they found that these people were already interested in astronomy and would probably vote for the bond issue anyway. Therefore, they set up telescopes on street corners, talking about the planetarium and passing out printed folders to all who stopped. They arranged radio talks, and in a downtown store window placed the model of the planetarium that is shown here. They put on a mail campaign, reaching all school science teachers, and church, civic, cultural, and scientific organizations. The local newspapers lent support to the planetarium project.

The site has not been chosen, but the Planetarium Forming Group suggests an area in the corner of Forest Park at Kingshighway and Oakland Avenue. However, the final location will be decided by the city plan commission, and actual construction will be under the board of public service.

The project now is in the hands of a bond issue supervisory committee, which decides priorities on the many civic activities that will be covered by the bonds sold each year; thus, actual construction of the planetarium may have to wait completion of other projects.

For a complete science center adjoining the planetarium, Mr. Ohlendorf's group proposes a natural history building, an aquarium, a science and industry building, and an auditorium.



This is a model of the proposed St. Louis planetarium. The building would be 100 by 125 feet, with two floors of exhibits, and would seat about 400 persons in a 50-foot planetarium chamber.

STELLAFANE IN 1955

Over 200 amateur telescope makers and friends attended the annual meeting at Stellafane, near Springfield, Vt., on August 20th, some coming from as far as California.

More than two dozen telescopes were exhibited, from a 2-inch refractor to a 12½-inch off-axis Cassegrainian reflector. These were judged by daylight for quality of construction, and at night for optical performance. Both first prizes went to Winfred Lurcott, of Cranford, N. J.

Observing conditions were excellent, and the crowd enjoyed an unusual opportunity to compare the appearance of a bright comet, 1955g, in telescopes of widely differing size.

The joint sponsoring societies, the Springfield Telescope Makers and the Amateur Telescope Makers of Boston, announced that the 1956 Stellafane gathering will be on August 11th.

NEAL J. HEINES

The passing of Neal J. Heines, of Paterson, N. J., on August 21st, has removed an important leader in American amateur astronomy. For many years an active member of the American Association of Variable Star Observers, he organized the AAVSO Solar Division.

This group of observers makes systematic counts of sunspots, from which they compile the American sunspot numbers. For years this work was sponsored by the National Bureau of Standards. In 1953 Mr. Heines retired from the Solar Division, and H. L. Bondy took over its direction.

In addition to his astronomical work, Mr. Heines was well known in musical circles, both as a singer and as a director of choral groups.

THIS MONTH'S MEETINGS

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Lone Star Gas Co. auditorium. Oct. 24, astronomical film.

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Oct. 11, Frank Hancock, "Man's Place in the Universe." Oct. 22, annual banquet, Dr. Gerard P. Kuiper, Yerkes Observatory, "The Moon."

Long Beach, Calif.: Excelsior Telescope Club, 8 p.m., home of Lou Bellot, 3701 Vermont Ave. Oct. 21, Chalmers Myers, "What Star Is on the Meridian?"

Minneapolis, Minn.: Minneapolis Astronomy Club, 8 p.m., old University of Minnesota airport. Oct. 14, field trip.

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Oct. 5, Dr. Harlow Shapley, Harvard Observatory, "The Clouds of Magellan: A Gateway to the Universe."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Oct. 1, Dr. Peter van de Kamp, Sproul Observatory, "Do Stars Have Planets?"

NEWS NOTES

By Dorrit Hoffleit

PALOMAR SKY ATLAS

The first section of the National Geographic Society-Palomar- Observatory Sky Survey has now been published (see page 299, July, 1954, *Sky and Telescope*). This section comprises 200 of the total of 1,758 photographic prints that will form the complete atlas.

The 48-inch Schmidt photographs will twice cover the three quarters of the sky visible from Palomar, once in blue light, once in red. They penetrate to a distance of 600 million light-years. Each 14 inches square, the maps of the completed atlas, if laid side by side, would cover the area of a tennis court.

In the August *National Geographic Magazine*, Dr. Ira S. Bowen, director of the Mount Wilson and Palomar Observatories, describes not only the achievement of this undertaking with the 48-inch Schmidt telescope—the world's largest of this type—but also some of the disappointments along the way. Perfect photographs were the goal, but roughly 45 per cent of the plates taken were rejected and had to be repeated, because of poor seeing, human error, or defects in photographic emulsions. There was one night of exceptionally fine seeing when the observers had forgotten to take the dust cap off the telescope! Dr. Bowen mentions this to show that "although we were dealing with the sublime, the making of the Sky Atlas was a very human operation."

The original plates from which the atlas is being reproduced are preserved in a vault three floors below ground in Pasadena; and copies on glass are also being stored for safekeeping in the dome of the 200-inch telescope at Palomar.

One important use of the atlas will be the selection of newly found objects to be studied in detail with the 200-inch reflector. The 48-inch Schmidt photographs on one plate an area about the size of the bowl of the Big Dipper, and is taking seven years to complete the survey. The 200-inch, which can photograph only about a quarter of the area of the moon at a time, would require 10,000 years to make such a survey.

THE SPEED OF LIGHT

A curious discrepancy between accurate measurements of the velocity of light may mean that the speed of light varies, according to Dr. J. H. Rush, of the Texas Technological College. Such a variation would have important implications.

The five earliest experimental determinations, made from 1876 to 1902, are much less accurate than more recent work. But six precise values obtained between 1906 and 1941 group around 299,776 kilometers per second, with uncertainties of the separate determinations ranging from ± 10 to ± 15 kilometers per second. Dr. Rush omits Michelson's 1926 determination of $299{,}796 \pm 4$, suggesting that it may be systematically off because of the necessary corrections for the long path of the light beam through the atmosphere.

Since World War II, seven new measurements by different methods cluster about 299,792 kilometers per second, and their uncertainties average less than half those of the prewar determinations. Thus the pre- and postwar averages differ by 16 kilometers per second. (Two other recent measurements, however, agree with the best earlier value of 299,776.)

Dr. Rush points out in *Scientific American* that modern techniques are now so precise that the next decade should reveal either the reality of a change in the velocity of light or the cause of the present discrepancies.

THE 25 LARGEST SUNSPOTS

Greenwich Observatory will soon publish a catalogue of the 762 sunspots from 1874 to 1954 that had areas of at least 500 millionths of a solar hemisphere. The 25 largest of these spots are described by H. W. Newton in the *Journal* of the British Astronomical Association.

The greatest of all spots in the past 80 years appeared in April, 1947. It may well be the largest in the whole history of sunspot observations. When at maximum size it covered 6,132 millionths of a solar hemisphere. Since 1874, sunspot groups have ranged up to 200,000 miles in length and 75,000 miles in width.

The giant spots do not differ markedly from average sunspots either in solar latitude or in the stage of the sunspot cycle when they appear. The durations of giant sunspots are often not commensurate with their large size. Of the 55 groups catalogued at Greenwich, six survived less than two weeks after peak area had been reached. The longest-lived group lasted over 170 days, from May to November, 1948. A group in 1919 persisted for 136 days; one single spot lasted over 116 days.

IN THE CURRENT JOURNALS

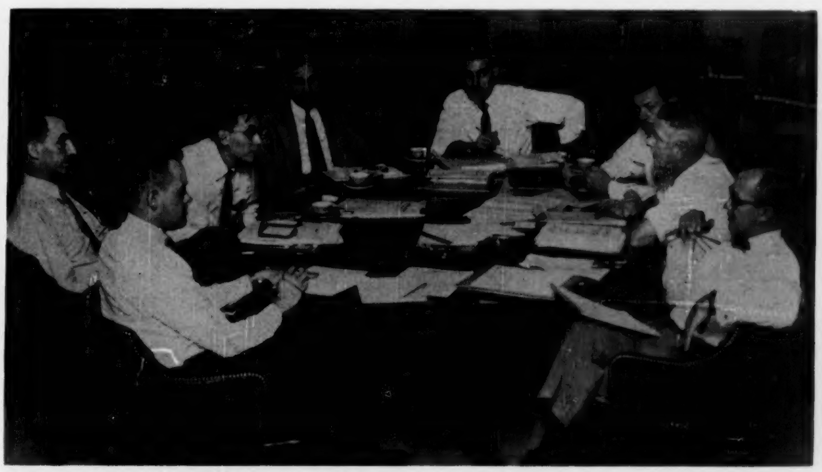
SATURN, by C. H. Cleminshaw, *Griffith Observer*, August, 1955. "This year marks the 300th anniversary of the discovery that Saturn is a ringed planet. It was in 1655 that Huygens, the famous Dutch astronomer, found the true nature of the two strange appendages which had been observed first by Galileo in 1610."

PLANETARIUM CONFERENCE

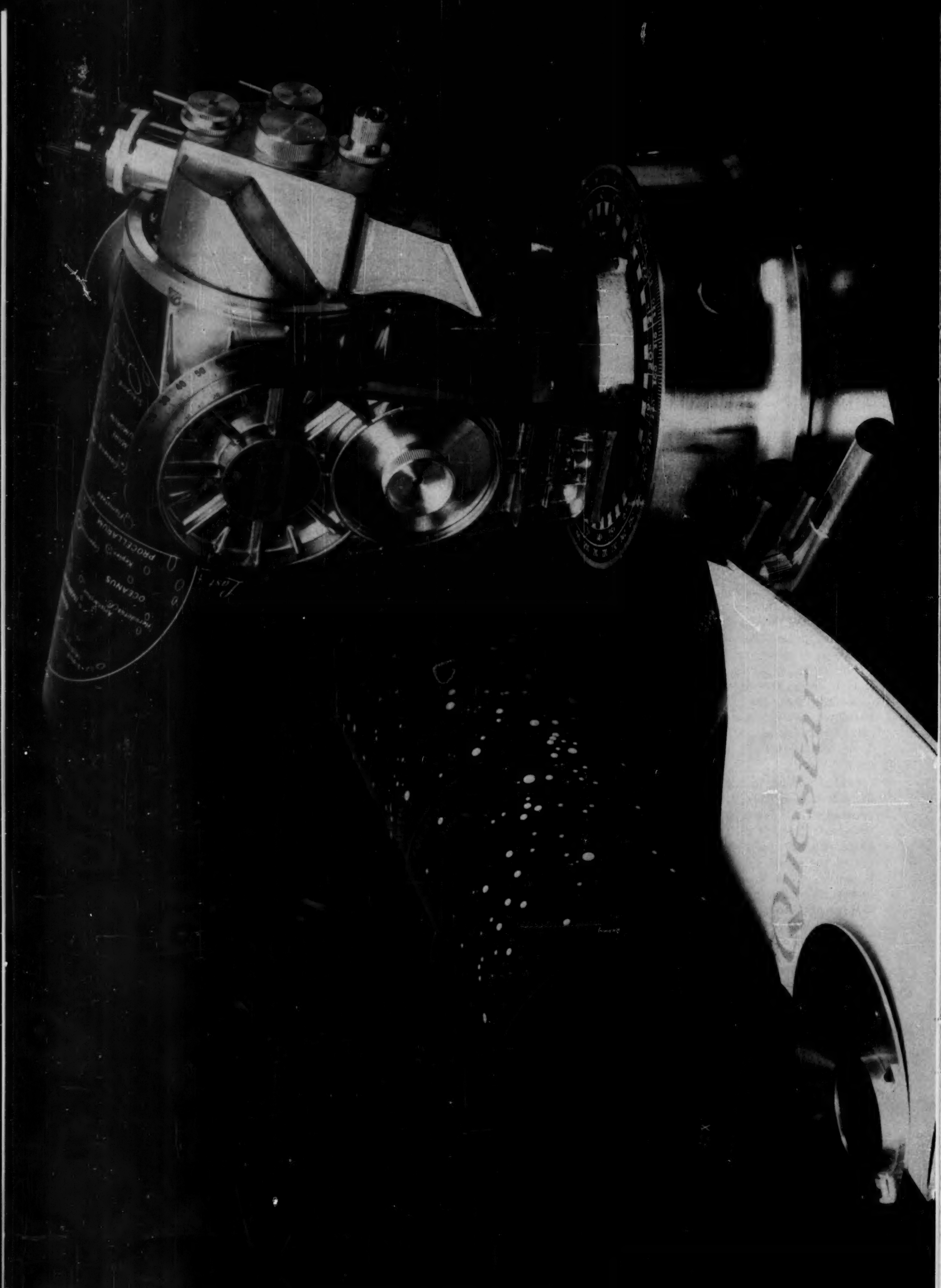
At a two-day meeting in June at the Morehead Planetarium, representatives of major planetariums discussed programming, demonstration techniques, public relations, exhibits, and the relationship of planetariums to communities.

Those present were, as seen seated around the table clockwise from left front: Joseph M. Chamberlain, general manager, American Museum-Hayden Planetarium, New York; Arthur L. Draper, director, Carl Wapiennik, staff physicist, and C. V. Starrett, foundation co-ordinator, all of the Buhl Planetarium, Pittsburgh; A. F. Jenzano, manager, Morehead Planetarium, Chapel Hill, N. C.; George Bunton, manager, Morrison Planetarium, San Francisco, and president of the planetarium section of the American Association of Museums; John Patterson, director of the soon-to-open Hayden Planetarium, Boston; and Dr. I. M. Levitt, director, Fels Planetarium, Philadelphia. Chicago and Los Angeles were not represented at the conference.

The possibility of forming an organization of officials of major planetariums will be considered at the 1956 meeting in San Francisco.



Officials of six major planetariums in the United States gathered in Chapel Hill, N. C., recently for their fourth annual conference. University of North Carolina Photo Lab picture.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BOOKS AND THE SKY

THE VIKING ROCKET STORY

Milton W. Rosen. Harper and Brothers, New York, 1955. 242 pages. $3.75.

NEXT to the German V-2 and the bazooka, the Viking upper-atmosphere sounding missile is probably the best-known rocket in the world. Primarily an instrument-carrying device, it has not been shrouded in military secrecy, and much of the data concerning its performance, capabilities, and accomplishments has been released.

The Viking holds single-stage missile speed (over 6,000 feet per second) and altitude (158 miles) records. It was developed and manufactured by the Glenn L. Martin Company under the over-all programing of the Naval Research Laboratory. Reaction Motors, Inc., built the 20,000-pound-thrust turbopump power plant that burns a mixture of liquid oxygen and alcohol.

A scale model of the Viking missile and cutaway views of the thrust chamber and engine components are now on view in New York City's American Museum-Hayden Planetarium. I was fortunate to have attended the opening ceremonies of this highly spectacular exhibit at the time of reviewing Mr. Rosen's book. There is also a model of the launching station, and the planetarium visitor hears a recorded commentary describing last-minute preparations in the blockhouse, nerve center of the firing operation. A voice is heard counting off the seconds. Then, with a brilliant blast, a miniature rocket roars upward.

Mr. Rosen's writing is admirably tuned to the rhythm of the launching station. "Forty seconds! Recorders on! Thirty seconds! Telemeter clear! . . . twenty, nineteen, eighteen, . . . I listen to the count, the same inexorable count that always drove us toward the decisive moment . . . six, five, four, three. . . . fire! My eyes fixed on the base of the rocket . . . the steam, the smoke, the angry roar and then—the wonderful, magnificent sight, as the fins rose slowly from the launching stand. Straight up it went—one by one the brilliant shock diamonds appeared in the long, slender flame."

The author provides a behind-the-scenes description of the events leading from the conception of the missile project through the firings of 11 high-altitude rockets. As such, the book will be particularly appealing to those engaged in rocket motor and missile engineering, and to upper-atmosphere physicists. But it should also interest the astronaut and the astronomer, into whose domain the Viking penetrates, if only for a few brief seconds.

A short survey of rocketry, notes on the origin of the Viking concept, a chapter on the upper atmosphere, an explanation of what a rocket is and how it operates, and a look at White Sands Proving Ground provide a very adequate introduction, setting the stage for what follows. Each Viking has its place in the book. Each missile is somehow different. For example, the memorable launching of Viking No. 4 from the U.S.S. *Norton Sound* near Christmas Island in the Pacific proved that the missile could successfully be handled under shipboard conditions.

The Viking Rocket Story reads like a diary. In many ways it is a diary. But it is also a biography of a missile—and of the men who built, handled, operated, and even tamed it. It is a story of triumph against a background of frustration, tension, hope, work, and disaster. As each slender missile roared upward the same questions were asked by the propulsion and missile engineers, the telemetering experts, the atmospheric research scientists, and the launching crew. How high would it go? Would each complicated instrument, valve, and

On display at New York's Hayden Planetarium is this Viking rocket, with side windows to permit views of its interior. It is 45 feet long, and partly made of sections from the wreckage of Vikings that have been fired into the upper air. American Museum-Hayden Planetarium photograph.

control function properly? Would this missile break a record? Mr. Rosen carries us into the sky:

"Sixty miles . . . seventy . . . eighty . . . ninety . . . it's a beauty . . . one hundred . . . one ten . . . one fifteen! There was pandemonium in the blockhouse. The men, unable to restrain their emotions any longer, broke into cheers and there was much hand-shaking and back-slapping . . . one thirty . . . and after a long time . . . one thirty-five . . . that's it—peak!"

Mr. Rosen has for some time been an articulate conservative when it comes to the space-flight theme. His attitude has no doubt been largely shaped by intimate association with his Viking missile. Certainly one of the important threads that ties together *The Viking Rocket Story* is the seemingly infinite number of things that go wrong before the word "takeoff" or "fire" can be uttered from the bunker.

A postlude picks up a few loose ends, ties in some significant achievements of the Viking program, and offers a preview of where we may go from here. Rosen believes that "much sooner than some people expect" artificial earth-satellite vehicles will be established, very small in size at first, and eventually larger, more complex, and more useful. Beyond this?

"The future can be only dimly perceived," he muses, but "as long as men have the curiosity and the courage, the exploration of space will continue to at least the farthest reaches of the solar system."

FREDERICK I. ORDWAY
Guided Missiles Division
Republic Aviation Corp.

OPTICAL GLASSWORKING

F. Twyman. Hilger and Watts, Ltd., 98 St. Pancras Way, Camden Road, London N. W. 1, 1955. 275 pages. 24s.

PROFESSIONAL lens manufacturers have for years used as a standard technical reference text Mr. Twyman's book, *Prism and Lens Making,* an excellent but voluminous treatise of 640 pages on the fabrication and testing of optical equipment. However, not only the size but the cost, about eight dollars, have prevented the workbench operator from having this book constantly available.

Now an abridged version of the large book has been prepared under the title, *Optical Glassworking.* Although written as a textbook for those engaged in or studying the manufacture of optical elements, through careful editing all pertinent information needed by the semiskilled and skilled worker has been retained.

From the first chapter, dealing with the historical background of glassworking, through the 24th, a discussion of reference books on optics, the serious optical worker will find numerous methods of handling various types of surfaces that can save hours of experimental and fruitless labor. To the amateur telescope maker, the majority of the chapters of this abridged work should be interesting and useful.

The story of abrasives and polishing materials is well presented in Chapter 3, at the end of which are many good formulas for cements, plasters, and varnishes—very important materials for blocking, holding, and protecting optical parts. However, in place of the plaster of Paris suggested by Mr. Twyman, many optical shops in this country use a special high-grade plaster, Hydrocal. This is a very fine-grain, hard plaster, with a minimum amount of shrinkage upon

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3" ALTAZIMUTH ($66 Down) with eyepieces for 171x, 131x, 96x, 67x, 48x	**$265**
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3" PHOTO-EQUATORIAL ($137 Down) with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x	**$550**
4" ALTAZIMUTH ($116 Down) with eyepieces for 255x, 219x, 170x, 122x, 84x, 61x	**$465**
4" EQUATORIAL ($196 Down) with eyepieces for 255x, 219x, 170x, 122x, 84x, 61x	**$785**
4" PHOTO-EQUATORIAL ($222 Down) with eyepieces for 255x, 219x, 170x, 122x, 84x, 61x	**$890**

The new 4" models with clock drive and astrocamera are described and priced on the back cover.

Prices include standard accessories. Additional accessories and eyepieces available for all models. Send check or m.o., or 25% deposit with balance C.O.D. or on monthly payments. All instruments fully guaranteed.

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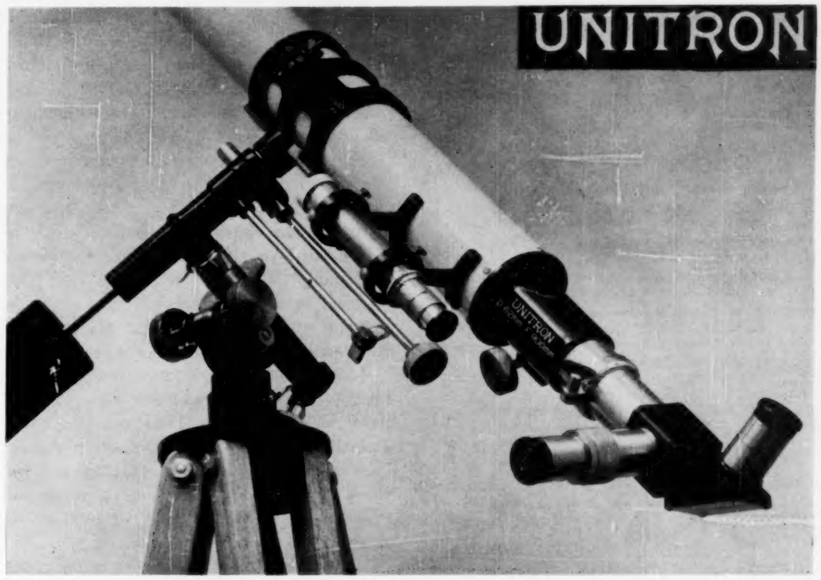
COMPLETE with the new UNICLAMP mounting brackets. Attach to telescope tube, or remove in a jiffy.

Only $9.75 postpaid

Here's the DUETRON Double Eyepiece — a New, Exclusive UNITRON Accessory



With DUETRON, two observers at the same time may use this UNITRON 2.4" Refractor.

The new DUETRON double eyepiece literally doubles the usefulness of your UNITRON. Two observers may use the telescope simultaneously and with equal comfort. The two eyepiece holders may be turned independently with respect to the telescope tube to suit the convenience of each observer. A focusing sleeve is provided so that the eyepieces used need not necessarily be of the same magnification. The DUETRON tube is interchangeable with the customary UNITRON drawtube and may be used with all models with the exception of the 1.6" Refractor.

"I used to be allowed to stay up and observe until 10:30 before I had a telescope," writes an embittered young observer. "Now, since my father bought 'me' a UNITRON, he rushes me off to bed by 9:30 so that he can use the UNITRON himself." DUETRON will restore harmony to this household since father and son may now explore the heavens together. DUETRON is also a boon to observers who buy their UNITRON in partnership since it eliminates completely the need to take turns. With DUETRON, more observers may be accommodated at star parties and the advanced members may provide valuable instruction to the beginners as they look through the UNITRON together.

DUETRON is but one of an ever-growing number of significant new accessories designed especially for UNITRONS. The ingenious design and careful workmanship of these accessories are characteristic of UNITRONS themselves. Just one more reason why you'll be glad that your telescope is a UNITRON.

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. . . and enjoy the luxury of these other UNITRON Features

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVE insures freedom from "clouding" with age.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to six eyepieces included with each instrument as standard equipment.
- FINEST MATERIALS throughout. DURALUMINUM TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No war surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for *both* declination and right ascension as well as rapid-motion controls.
- ALTAZIMUTH MODELS have slow-motion controls for *both* altitude and azimuth as well as clamps for both co-ordinates.
- VIEW FINDER with crosshair eyepiece gives wide field of view.
- RACK-AND-PINION FOCUSING for accurate adjustment.
- Choice of UNIHEX Rotary Eyepiece Selector (see page 522) or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The erecting prism system may be used with *any* of the eyepieces to give the same complete range of terrestrial magnifications as for celestial observation.
- STURDY TRIPOD may be folded for convenient storage.
- SUNGLASS for solar observation.
- SUN PROJECTING SCREEN is standard equipment on 3" and 4" Equatorial Models and available for other Models.
- Complete operating INSTRUCTIONS provided.
- FITTED WOODEN CABINET for storage of telescope and accessories. Tripod case.

See page 522 and the back cover.

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.

drying; it is excellent for blocking lenses and prisms and for holding forms.

The use of semiautomatic and automatic shaping machines for optical elements is important in modern mass production. The section in Chapter 4 on roughing by abrasive wheels and diamond laps is a good account, illustrated with the clearest drawings and photographs the reviewer has seen on this subject.

The use of test plates, or proof plates as they are called in England, is well covered in Chapter 9. Any amateur planning to build a reflector with a sealed tube to prevent air currents from bothering the seeing will find the part on plane-parallel plates a great help in making the window to be placed over the upper end of the telescope tube.

The reader is introduced briefly to the interferometer, a valuable test instrument, in Chapter 10. Those wishing more knowledge of the interferometer should consult the unabridged edition of this book and another Hilger and Watts publication, *Modern Interferometry*, by Candler.

The next two chapters cover silvering and evaporating processes, and the testing of optical glass. Modifications of the Brashear method of silvering are given, as well as two interesting processes, one for half-silvering and the other for rapid high-efficiency silvering of glass and plastics by chemical means. Careful testing of optical glass, as described by Mr. Twyman, will prevent the amateur from spending hours of work on blanks that could never hold a good figure because of strain, or which would give inferior definition due to striae.

Although of special astronomical interest, Chapter 13, "Large Object Glasses and Mirrors," cannot be considered as a detailed instruction manual for telescope makers; it is definitely superficial in its treatment, but it makes interesting reading. From the historical standpoint, it contains many little-published facts. For instance, I learned more here about Henry Draper's methods of working optical surfaces than I did during a visit to his workshop and observatory at Hastings-on-Hudson nearly 20 years ago.

There are two appendixes, the first on the making of polarizing prisms. The second is an excellent glossary of terms used in the optical industry—each item is given in English, French, and German.

Only one error was found. On page 73 both pictures show convex lenses being worked; there are no concave lenses shown as is stated on page 72.

The caliber of the pictures and drawings is exceptionally high and reflects the careful preparation that went into this book. The abridgement has not reduced the excellence of Mr. Twyman's work.

ROBERT E. COX
Optical Research Laboratory
Boston University

VOCATIONAL AND PROFESSIONAL MONOGRAPHS: ASTRONOMY

Freeman D. Miller. Bellman Publishing Co., Cambridge 38, Mass., 1955. 32 pages. $1.00, paper bound.

FOR ONE who may be examining the possibility of a career in astronomy this small paper-bound pamphlet is a must; for one who ever advises young people on astronomy it is also a must. Others interested in astronomy or the life of an astronomer will find here a surprising wealth of useful information, some of it not generally known. The booklet is number 72 of a series on various professions and vocations and is a thoroughly rewritten version of the original edition of 1947. Professor Miller, of the University of Michigan, an experienced investigator and teacher, is highly qualified to summarize present-day career opportunities for the astronomer.

The pamphlet contains a brief review of the history of astronomy and of the several branches of modern astronomical research: instruments, stars, sun, solar system, our galaxy and others, the universe, and practical astronomy. Then are described a typical observatory and its staff, equipment, research program, teaching program, and public work. The author writes too of the attractiveness of astronomy as a career and of the personal qualifications an astronomer ought to have—or have most of. Such qualifications range from "a lively curiosity about natural phenomena" and intellectual integrity to lecturing ability and manipulative aptitude. Of prime importance is a love of astronomy that is strong enough to offset the relatively low salary scales.

A typical program of college and graduate courses and requirements is outlined, and includes such topics as course work in related fields, language requirements, costs, and graduate assistantships. It is stressed that graduate work through the Ph.D. degree is necessary today for almost all job openings in professional astronomy. There is also a list of some of the institutions in the United States that have active departments of astronomy.

Employment opportunities for both men and women are considered. It is emphasized that the field of astronomy is very small (perhaps 300 openings in the country), but that nevertheless there is nearly always a good job for a very good person. Because a majority of astronomical posts involve college teaching and therefore are associated with institutions of higher learning, the author summarizes several aspects of an academic career, such as salary, promotion policy, and retirement. Other types of astronomical work, such as planetarium lecturing, are briefly described. Finally there are brief but useful listings of professional and amateur organizations of astronomers, periodic publications, basic books on astronomy, and a few astronomical movies.

Here in this small booklet are nearly all the answers to general questions one might ask about a career in astronomy. The author's account is terse, lucid, and without minimizing the occasional aches catches well the healthy spirit and excitement of the astronomer's life and work.

STANLEY P. WYATT, JR.
University of Illinois Observatory

NEW BOOKS RECEIVED

NON-EUCLIDEAN GEOMETRY, *Roberto Bonola,* 1955 reprint of 1911 edition, *Dover Publications.* 429 pages. $3.95 cloth, $1.90 paper.

This is a translation of a standard Italian work on the history and nature of non-Euclidean geometry. In the same volume are reprinted the classic essays by Lobachevski and Bolyai on the subject.

WHAT'S NEW AT EDMUND'S

by Norman W. Edmund

Dear Fellows:

Here is terrific news — a sale of war-surplus telescopes at low, low prices!

Recently a large lot of telescopes was put on the selling block. Even though I bid low and was successful, it took a lot of money. Then, big tractor-trailer loads started to arrive one after another.

The only thing to do was to run a real sale. Price them to move fast! So that's what we have done — telescopes that cost the government $200.00 and $75.00 — yours for only $12.50 and $7.50!

You're not only getting low prices — but real quality, too. The Army's quality standards for manufactured telescopes are extremely high. Thus the images you get are clear and brilliant.

These scopes make excellent finders for astronomical telescopes. They are about the only ones available to you at these prices with illuminated reticles that you can easily see at night.

How long these sale prices will be in effect, we don't know. So don't take any chances. Order now. You just can't go wrong at these prices.

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$200 VALUE FOR ONLY $12.50 POSTPAID

BIG 2" OBJECTIVE—KELLNER EYEPIECE—AMICI ERECTING PRISM

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This is Edmund's biggest bargain offer in an entire decade. Weight of this instrument is 5 pounds. Field is 6°, exit pupil is 0.243 inch. Excellent for finder on an astronomical telescope. Ideal for use as a mounted telescope for terrestrial observation. Also can be used for telephoto photography. Objective lens can be removed and a tube added with a longer focal length eyepiece to convert to a high-power astronomical telescope. The focusing 28-mm. F.L. eyepiece alone is worth more than $12.50. These telescopes were designed for spotting airplanes in the sky and have excellent resolving power and definition. The image is sparkling clear and bright — will delight you. Adjustable focus from 15 feet to infinity. These instruments are in good condition — practically new. You can buy this exceptional bargain with absolute confidence. In accordance with the policy prevailing on all Edmund merchandise, we guarantee complete satisfaction or your money back.

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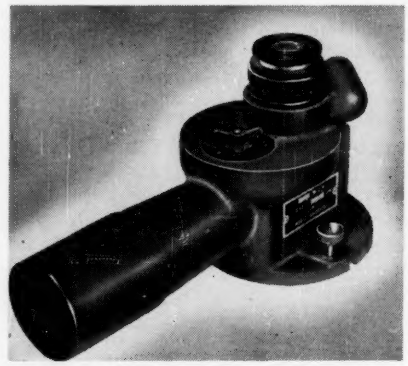

M-70 3-POWER TELESCOPE

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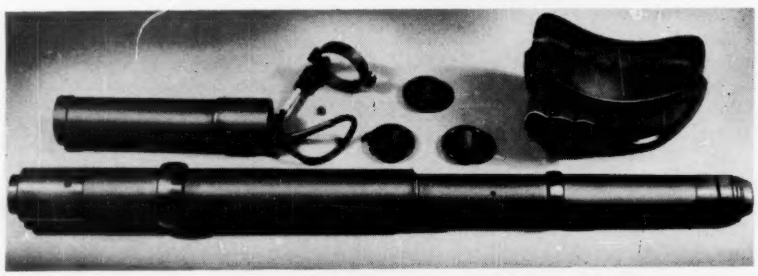

Another fine quality instrument throughout — produced by America's leading optical manufacturers. Made of sturdy steel and brass — weight 5 pounds. Length 22½". 12° 19' field! Telescope consists of a Kellner eyepiece, reticle, 2 achromatic erector lenses, 1 achromatic objective lens (25-mm. diam.), and a protective window. All optics are low-reflection coated. Also included: a rubber eyeguard, instrument light with rheostat that clamps to scope for illuminating reticle (takes standard flashlight batteries), and amber, red, and neutral filters for snapping on to eyepiece.

By removing 3 screws, you can separate scope into 2 pieces, one of which makes an excellent 6-power finder for an astronomical telescope on which reticle can be illuminated for night use. To give you some idea of the intrinsic value you are getting here — as surplus, the lenses alone would cost double the price we are asking for the entire instrument. Bear in mind, too, that the eyepiece by itself can be used for an astronomical telescope.

Stock #80,052-Y Completely boxed with protective absorbent, exactly as received from Army .... $7.50 ppd.

Stock #80,051-Y Telescope only .... $4.00 ppd.

THE MOUNTING RINGS FROM OUR STANDARD 7-POWER FINDER CAN BE USED ON THE ABOVE M-70 TELESCOPE

Stock #50,075-Y Ring mounts per pair .... $4.95 ppd.

EDMUND SCIENTIFIC CORP.

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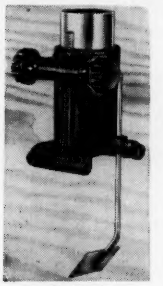
Real Quality at Bargain Prices
Make Wonderful Refractors

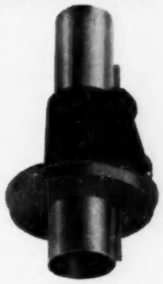
For three years we checked U.S., German, and Japanese manufacturers looking for one who could produce really good telescope objectives at a low price. A few times we ordered samples only to be disappointed in quality or final price. Finally, we found a Japanese optical engineer who designed some excellent astronomical objectives. We place orders with him. He then has these made, checking each one for quality. Thus, we are able to offer objectives we believe to be as good as those selling for two or three times our price.
Our 3" and 4" diameter objectives are air-spaced achromats, as air-spacing gives the lens designer four surfaces with which to correct aberrations, instead of only three as in a cemented achromat. The results are a beautiful, color-free image, sharp, clear, with very flat field, no bad zones, and full correction against coma.

Stock No.	Diam.	F.L.	Price	Comments
30,166-Y	3"	45"	$28.00	Not coated
30,190-Y	3"	45"	32.00	Coated
50,106-Y	4"	60"	60.00	Not coated
50,107-Y	4"	60"	69.00	Coated on four surfaces

Metal cells are available for the objectives above.
Stock #70,063-Y..........$11.95 for 4" objective
Stock #70,064-Y..........$10.95 for 3" objective

Rack & Pinion Eyepiece Mounts


For Reflectors


For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

HUYGENS EYEPIECES

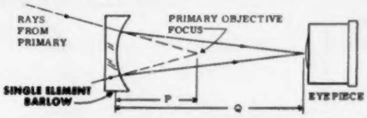
Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys at these low prices!

HUYGENS TYPE — STANDARD 1¼" DIAM.
6 mm. (¼") Focal Length
Stock #30,063-Y .... $8.50 ppd.
12.5 mm. (½") Focal Length
Stock #30,064-Y .... $8.00 ppd.

COMBINATION EYEPIECE—10 mm. and 20 mm.
Stock #30,065-Y .... $9.00 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER

with a BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power.
The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q!
ACHROMAT OR SIMPLE BARLOW? An achromatic Barlow lens will give best results, but our low-priced single-element lens will give you 90% of the performance of the achromat. In fact, on and around the axis, the image will be just as good, with slight additional color at the edges of the field. SINGLE ELEMENT BARLOW — FOCAL LENGTH 1-5/16". Our short focal length means that you do not have an unwieldy long tube at the eyepiece.

Stock #30,175-Y. Unmounted, O.D. 1-3/16". Coated. Fits in tubing listed below. $3.00 ppd.
Stock #30,140-Y. Mounted Achromatic Barlow Lens .... $15.00 ppd.

30-day Money Back Guarantee as with all our Merchandise!

BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16". O.D. 1-5/16". To fit single-element Barlow above.
Stock #40,165-Y .... $1.25 ppd.

7X — FINDER TELESCOPE — ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts $9.95
Stock #50,075-Y Ring mounts per pr., $4.95

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	7"	7½"	60"	Spiral-wound paper	4.00
85,011-Y	2⅞"	3"	48"	Aluminum	6.00
85,012-Y	3⅞"	4"	60"	Aluminum	8.75
85,013-Y	4⅞"	5"	48"	Aluminum	9.00
85,014-Y	6⅞"	7"	60"	Aluminum	15.00

All tubing is shipped f.o.b. Barrington, N. J.

MOUNTED ERFLE EYEPIECE

68° FIELD OF VIEW

Consists of 3 coated achromats in metal mount with spiral focusing. F.L. 1¼". Diam. 54 mm., length 54 mm. War surplus. Govt. cost about $84.00. This is the type war-surplus bargain that will be talked about in years to come. Buy while you can.
Stock #5160-Y, $12.50 ppd.

ADAPTER

Provides 1¼" diameter mount to fit standard eyepiece holders.
Stock #30,171-Y .... $3.95 ppd.

1¼" diam.

WAR SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, F.L. 28 mm., eye relief 22 mm. An extension added. O.D. 1¼", standard for all types of telescopes. Govt. cost $26.50.
Stock #5223-Y, $5.95 ppd.

MAKE A SUN DIAGONAL

Because it is unsilvered, this PENTA PRISM transmits only .0016 of the light it receives, making it an excellent sun viewing diagonal, if used with proper precautions. Entrance and exit faces 1" and 1" approximately.
Stock #3262-Y $3.75 ppd.

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The same fine mirror as used in our Palomar, Jr., polished and aluminized, lenses for eyepieces and diagonal. No metal parts.
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Designed by Armand Spitz. Projects nearly 400 stars, more than 70 constellations in their correct relationships. Use it in any darkened room of the house, project it on walls and ceiling. No batteries, works on ordinary household current. Two simple adjustments that show you the sky as it appears from any point in the Northern Hemisphere . . . for any time of night . . . for any month of the year! Rheostat brightness control. A 32-page book included free of extra cost. Contains valuable information about the stars, provides easy identification of the constellations. Also FREE — illuminated pointer.
About 14" high on a 7" x 7" base. Projection sphere 7" diameter. Weight 3 lbs. Now available supplementary spheres for Southern Hemisphere and "Sky Zoo."
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Ground, polished, aluminized, silicon monoxide overcoated. You can't buy better quality. Remember, good Spherical Mirrors of f/10 and higher, are perfectly satisfactory for reflecting telescopes.

STOCK NO.	DIAM.	F.L.	PRICE
50,082-Y	3"	30"	$9.95
50,051-Y	4¼"	45"	15.00

360° SETTING CIRCLE

Made of heavy black plastic material with white markings divided into 1 degree. Numbered every 10 degrees. Diameter 4". Hole diameter 2⅞" with a ledge 3⅛". We also include, free of charge, the U.S. Air Force true air-speed computer, which is an instrument made of two disks of black plastic. Use with the setting circle if you make your own.
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STAR SPECTROSCOPE — Imported! Doubles the usefulness of your Telescope. 2¾" long.
Stock #50,023-Y .... $32.75 ppd.
60° SPECTROMETER PRISM — Polished surfaces 18 mm. x 30 mm. — flat to ½" wave length.
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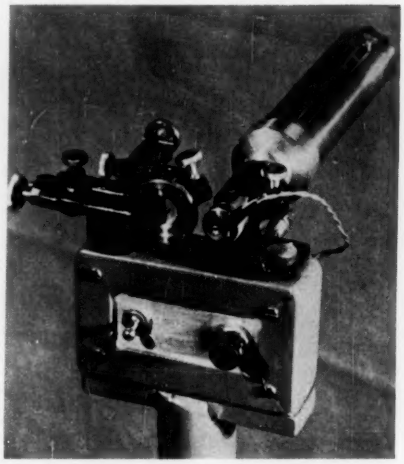
GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

An Experience with the Dall Null Test

FOR TESTING parabolic telescope mirrors, a null method has been devised by H. E. Dall, which differs from the familiar Foucault knife-edge test by the insertion of a plano-convex simple lens between the mirror and the slit (or pinhole) that illuminates it. When the reflected beam is cut, at the center of curvature, by the knife-edge, the whole mirror surface darkens uniformly, if the mirror is properly corrected.

The spherical aberration of the lens closely neutralizes that of the mirror. Interpretation of the knife-edge shadow is much easier than in the original Foucault test, particularly for mirrors of short focal ratio. Using Dall's test, the amateur can produce surfaces with aberrations reduced to whatever minimum his patience and skill will allow.



This is the Warkoczewski apparatus for the null test. The knife-edge assembly is at the left.

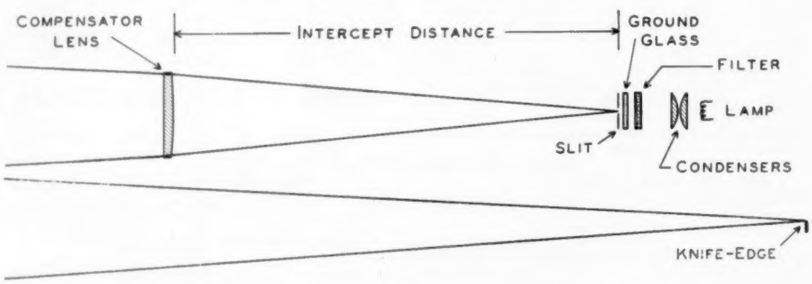
There is a complete description of the test in *Amateur Telescope Making—Book III*, pages 149-153, and an earlier version is reported in the April, 1948, issue of *Sky and Telescope*, page 161.

The following tells of my experiences in figuring a 16⅜-inch pyrex disk of f/6 to a quality that probably would not have been possible without the Dall test. After months of effort without success by the usual tests, the surface was made spherical and the disk laid away in the hope of better results at a future time. About a year later the apparatus for the Dall test was assembled, and polishing was finally resumed on February 16, 1955, after a friend told me he had used the null test for an 8-inch f/4.5 paraboloid.

My Foucault test equipment comprises a ¾" tube housing a No. 46 GE bulb, condensing system, adjustable slit, and a knife-edge holder with micrometer movement horizontally and along the axis of measurement—all mounted on an adjustable and movable stand. To adapt this rig to the Dall test, I cut threads on the tube containing the light source and screwed onto it a larger tube holding the compensator lens. The axial position of this lens was adjustable within the tube.

The slit width was made about 0.001" by placing cellophane of that thickness between the knife-edges and squeezing them together. The length of the slit was limited to 0.015" by drilling a hole with a No. 80 drill in a tubular fitting which was screwed behind the slit. A condensing-lens system was adjusted for the minimum-size spot of light on the slit, and a red filter was inserted between the light source and condenser. For the compensator lens, I used at first a 1-inch war-surplus plano-convex lens with a focal length of 10 inches, carefully spaced from the slit to the recommended distance for this mirror and lens.

With the setup approximately at the center of curvature and the compensator lens installed, I expected a null indication, but a glance past the knife-edge showed the mirror only illuminated by room light. Considerable jockeying of the test stand was needed to locate the elusive



The arrangement for testing a mirror by Dall's method. The plano-convex compensator lens should have a focal length between 1/5 and 1/20 of the mirror under test; the actual ratio determines what the distance between lens and slit should be.

reflection. Even then, only a part of the mirror was covered with light. A check with the knife-edge showed that the setup was actually behind the center of curvature, and it had to be moved up nearly three inches. When this was done, the entire mirror filled with light. But further checks showed improper shadow movement, indicating that the slit and lens were misaligned with respect to the mirror.

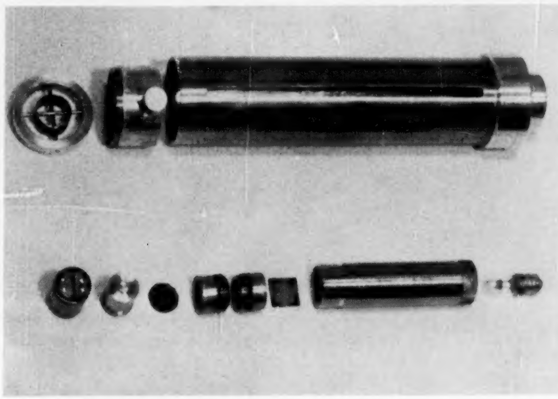
This condition was easily cured by placing a bull's-eye target on the open end of the tube containing the compensator lens. The target reflection was then centered on the mirror with the aid of an Everest pin stick placed on the mirror's horizontal diameter. First, the reflection was shifted until a horizontal bar of the reflection was superimposed on the Everest stick; then the reflection was shifted horizontally until the target circle fell between similar pins. This process required modifying the base of the light-slit-lens tube to provide angular adjustment in a vertical plane. Thereafter, these adjustments were made prior to each null test (for which, of course, the target was removed from the lens tube).

The general illumination of the mirror was poor, since the photographic filter was not dense enough to smooth out the bright spots and prismatic effects of the filament light source (a 6-8-volt, 0.25-ampere bulb operated at a maximum of 10 volts). Roughing the filter with fine carbo worsened matters, for this made the mirror look grainy. The trouble was cured by replacing the filter with a disk of dark red celluloid near the slit, and a fine-ground quartz crystal between the bulb and the condenser. This provided a smooth, brilliant illumination of the mirror.

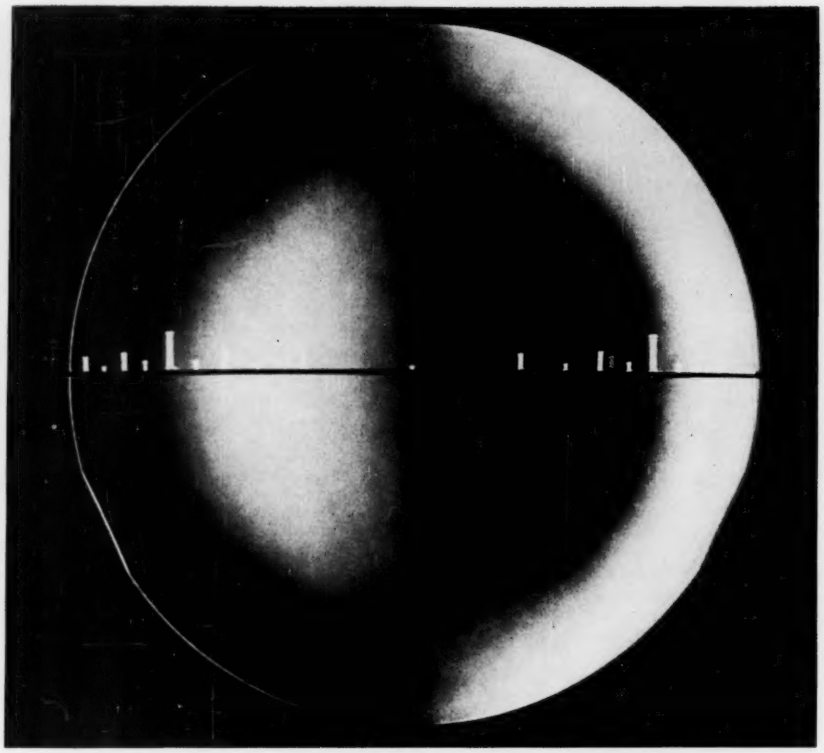
After all difficulties had apparently been squared away, the spherical mirror, which had looked quite "flat" under the Foucault test, now exhibited the shadows of an oblate spheroid of very long radius. The problem was now to make the mirror appear flat as viewed with the Dall test.

Since apparently a relatively large amount of glass was to be removed, I began correcting the mirror with a 12½-inch star lap, and a vigorous polishing period resulted in a central depression with a high surrounding crest and the outer area turned down. With the null test, the worker can be easily led astray into doing just the opposite of what he would otherwise do as a corrective measure. In this case, one spell of polishing down the edge zones quickly served to set my sights straight and the error was thereafter avoided.

As the proper corrective measures were applied, the mirror gradually took on a flat appearance, but I was puzzled by the appearance of a dark area at the left edge which jumped into prominence long before any other portion of the mirror darkened. Since no corresponding



Here the testing apparatus is taken apart. Above are the bull's-eye, used in insuring correct lining up, and the housing that carries the lens; below, from the left, are the slit, the attachment that limits its length, red filter, two condensing lenses, diffusing screen, the containing tube, and light bulb.

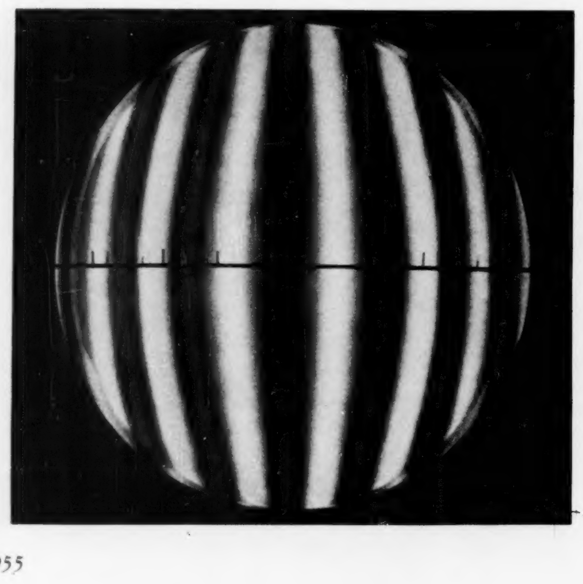


The Foucault knife-edge test gives these shadows on the finished 16-inch mirror. An Everest pin stick is seen in front of the mirror.

lighter area could be discerned at the right edge, the possibility of a turned-down edge was discounted at first. However, I found that the shadow appeared when the separation of the slit image and the knife-edge was about three slit widths. Reducing the radius of the edge zone eliminated the condition completely.

As the mirror finally assumed the proper appearance, marked only by faint zones, trouble occurred in the form of astigmatic effects that had not been discernible when the mirror's figure was irregular. However, the Foucault test did not show this, and the Ronchi test gave the straight lines indicative of a spherical surface. It was very disturbing that the null test seemed to show up a condition unobservable at any time with the other tests. Quite a deep path was worn into the concrete floor between test stand and mirror to rotate the latter and test on several diameters. Nevertheless, an eyepiece and pinhole test gave the mirror itself a clean bill of health.

These shadow progressions were quite variable. At times, shadows appeared simultaneously left and right. Once the mirror blanked out except for a 90-degree sector in the upper left. This behavior



The Ronchi test gives this pattern on the 16-inch mirror. In this test, which might be regarded as a modification of the classical Foucault test, a grating replaces the knife-edge. When the bands are straight, the mirror is spherical; a paraboloidal mirror gives bands that are portions of parabolas.

was not due to misalignment of slit and knife-edge, and their linear separation was always less than the allowable two per cent of the mirror's focal length.

Eventually the shadow trouble was traced to the compensator lens being off center within its tube. This fact was established by chucking the entire assembly in a lathe and watching the circular reflection of a sheet of graph paper. After the lens was correctly centered, there was no further difficulty with odd shadow effects.

But there still remained an upsetting discrepancy that for a time lessened my confidence in the Dall test. While the figure of the mirror appeared good by this test, measurements by the Foucault method showed it to be overcorrected by 0.060" at the edge, and by almost half that amount at the 50-per-cent zone. The overcorrection was more than three times the allowable deviation. Rechecking computations and remeasuring lens spacing showed all to be correct, and the blame for the test failure was properly assigned to the war-surplus lens.

A new lens of crown glass was made for me by a local firm, and when this was installed the test showed the same figure and degree of overcorrection that the Foucault method did. If you use the Dall test, know your lens! Another worker who used an achromat rather than the specified simple lens also got an overcorrected mirror.

Work on the mirror now proceeded with confidence in the Dall test. The mirror was adjudged finished on May 11, 1955, after almost three months of spare time had been spent in changing the surface from a completely polished spheroid to its present form. Zonal measurements of the completed mirror, inspection of the smooth-flowing Ronchi lines, illustrated here, and the degree of flatness under the null test all seem to substantiate the conclusion that the figure of the mirror is good.

S. J. WARKOCZEWSKI
1416 E. 65th St.
Kansas City 10, Mo.

EYEPIECE STORAGE

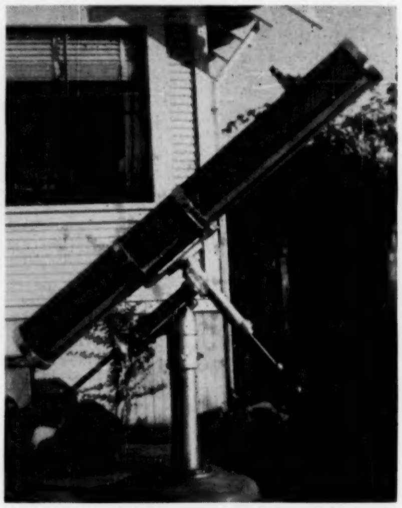
If, like most other amateur observers, you are always misplacing eyepieces, here is one way to save time and trouble. All that is needed is a small wooden filing-card cabinet such as may be purchased in the local five-and-dime store. Mine is 7" by 3" and 3" in depth. Into the top of this is fitted a piece of $\frac{1}{4}$" plywood, through which I had cut holes $1\frac{1}{4}$" in diameter, one for each eyepiece. The plywood was then secured with small wood screws into the card case.

This box is handy for transporting the eyepieces and for keeping them at the telescope. When the eyepieces are not in use, the box protects them from dust and dirt.

J. M. WILLIAMS
P. O. Box 268
Saco, Me.

TELESCOPE MAKER USES INSTRUMENT AT SCHOOLS

As a pattern maker with a small brass and aluminum foundry I can make up any kind of mounting. The picture shows the 6-inch reflector I built in 1953. I have visited schools with it, one 75 miles south of here where my daughter was teaching. In order to haul it in my car I had taken the instrument apart—



the children assembled it, and I stayed with them for half a day. It is surprising how interested youngsters are in astronomy.

To get a good sky for observing, we have to travel about 30 miles inland from here to higher levels, about 4,000 feet elevation.

A. I. BARNWELL
2402 Myrtle Ave.
Eureka, Calif.

GROOVING PITCH LAPS

Many methods have been suggested for making channels in pitch laps. Hacksaws, ripsaws, and knives have been used, but all of these may chip the pitch and disfigure the facets, leaving an unsatisfactory lap.

I have tried the following procedure with excellent results. First, pencil lines are drawn on the lap to mark where the channels are to go. A stiff metal rod, about 3/16" thick, is heated over a range burner to a high temperature, and then is pressed down quite hard on one of the penciled lines. Do not lift the rod, but pull it lengthwise out of the channel. It will take much pitch with it. The rod should be wiped clean and reheated before making the next channel.

C. A. OLSON
6520 S. Oakley Ave.
Chicago 36, Ill.

GLEANINGS is always ready to receive reports and pictures of amateur instruments and devices, and is open for comment, contributions, and questions from its readers.

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Air-spaced

3 1/4" diameter — 48" focal length — f/15

We offer the lowest priced, hand-corrected, precision, American-made astronomical objective, *mounted in a black anodized aluminum cell.* Our reputation has been established over the years as the most reliable source of high quality astronomical lenses. We have the largest selection of diameters and focal lengths in the United States available for immediate delivery.

"Those in the know" BUY FROM US BECAUSE:

1. Hand-corrected
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6. 3 1/4" CLEAR APERTURE f/15
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Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problem.

Air-spaced Achromatic Objective (uncoated) .... **$28.00** postpaid

Coating if desired .... **$ 4.00** extra

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power. They can readily be used with eyepieces of only 1/4" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100.

Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2 1/8")	300 mm (11.8")	$12.50	81 mm (3 3/16")	622 mm (24 1/2")	$22.50
54 mm (2 1/8")	330 mm (13")	12.50	83 mm (3 1/4")	660 mm (26")	28.00
54 mm (2 1/8")	390 mm (15.4")	9.75	83 mm (3 1/4")	711 mm (28")	28.00
54 mm (2 1/8")	508 mm (20")	12.50	83 mm (3 1/4")	762 mm (30")	28.00
54 mm (2 1/8")	600 mm (23 1/2")	12.50	83 mm (3 1/4")	876 mm (34 1/2")	28.00
54 mm (2 1/8")	762 mm (30")	12.50	83 mm (3 1/4")	1016 mm (40")	30.00
54 mm (2 1/8")	1016 mm (40")	12.50	110 mm (4 3/8")*	1069 mm (42 1/16")	60.00
78 mm (3 1/16")	381 mm (15")	21.00	110 mm (4 3/8")	1069 mm (42 1/16")	67.00

*Not coated

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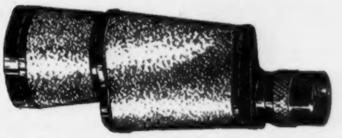

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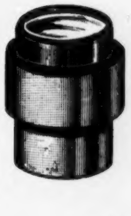
10 x 50	30.25	16 x 50	39.75
20 x 50	49.75	20 x 50	54.25



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Known among amateurs as the "Giant Jaegers," this is the finest wide-angle eyepiece ever made. It gives a flat field. It is mounted in a focusing cell. This is an Erfle eyepiece, 1 1/2" effective focal length, with a clear aperture of 2 3/16". It may be used as a Kodachrome viewer, magnifying seven times.

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32 mm (1 1/4") F.L. eyepiece contains two achromatic lenses.
Coated lenses **$13.50** Not coated **$12.50**

35 mm (1 3/8") F.L. symmetrical eyepiece contains two cemented achromats.
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A. JAEGERS

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

A Drawing of the Lunar Straight Wall

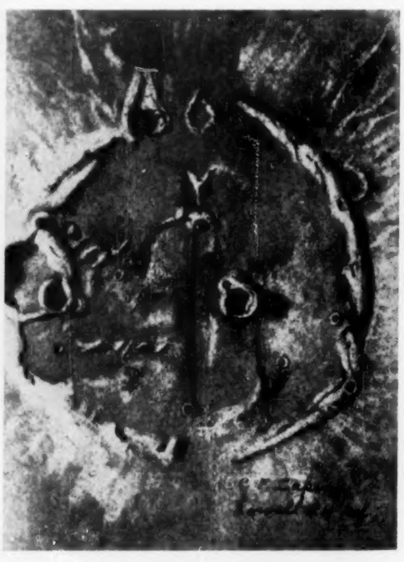
LYING between the craters Thebit to the west and Birt to the east, the lunar Straight Wall is a fault some 60 miles long and about 500 feet high. It was once mistaken for an artificial work, and even called the Railway. Subsequent observations showed it to be a fault scarp in the surface plain of a "submerged" crater, which can be seen easily only when the sun is low, as in my drawing reproduced here.

This observation was made with the 24-inch refractor of Lowell Observatory on March 31, 1955, from 8:00 p.m. to 11:53 p.m. MST. The aperture of the telescope was reduced to between 15 and 20 inches, with powers of 240x and 580x. I used Wratten filters (Nos. 8, 12, 15, 21, and 57) to lessen irradiation and to heighten contrast. At the time of observation, the sun's colongitude was increasing from 11°.5 to 13°.5, so that the terminator is just outside the right edge of the drawing.

On the following evening, when the sun's colongitude was about 24°, I observed the same region again for the appearance of the surface features under different lighting conditions, and to check the drawing for the positions of the many small craterlets, rills, and clefts recorded.

According to J. E. Spurr's *Geology Applied to Selenology*, the Straight Wall is a fault scarp, formed after the cooling of Mare Nubium, with its upthrow on the west. Traces of its extension, or of a closely parallel fault, can be noted on the floor of the crater Hell, well toward the south. To the west of the Straight Wall, the smooth surface does not appear to be that of Mare Nubium lava, but completely melted-down material. The difference in appearance between these two portions of the surrounding plain can be noted under a higher sun than when my drawing was made.

CHARLES F. CAPEN, JR.
2021 S. State St.
Springfield, Ill.



The region of the Straight Wall at lunar sunrise, drawn by Charles F. Capen, Jr. The uneven width of the shadow shows that the height of the escarpment is not uniform. Large craters left and right of the wall are Thebit and Birt, respectively.

COLONGITUDE—AN AID TO LUNAR OBSERVERS

THE APPEARANCE of a lunar surface feature changes so markedly under varying illumination by the sun that it is useful to be able to specify concisely where the moon's terminator is at the time of an observation. The terminator is the dividing line between light and dark on the moon; it is the sunrise line from new moon to full and the sunset line from full moon to new.

The colongitude of the sun is a convenient way of indicating the terminator position. It is an angle, centered at the moon and increasing at the rate of about 12 degrees per day, that reaches 360° each lunar month when the sun is rising at selenographic longitude 0°. Generally speaking, the sun's colongitude is near 0° when the moon's phase is first quarter, 90° at full moon, 180° at last quarter, and 270° at new moon. But it is less accurate merely to specify the moon's age, for in using colongitude the librations of the moon are already allowed for.

The *American Ephemeris and Nautical Almanac* lists the sun's colongitude for every day, for instance, on pages 440-447 of the volume for 1955.

For planning systematic lunar observations, colongitude can be used to tell when to look for a particular formation on the terminator. If **L** is the selenographic longitude of a crater, then to a close approximation sunrise occurs at that crater when the colongitude **C** is $360° - \mathbf{L}$; noon at that crater is when $\mathbf{C} = 90° - \mathbf{L}$; and at sunset, $\mathbf{C} = 180° - \mathbf{L}$.

For example, the crater Plato is in selenographic longitude −9°.0. Therefore, Plato's sunrise, noon, and sunset occur when the sun's colongitude is 9°.0, 99°.0, and 189°.0, respectively; the corresponding dates can be obtained from the *American Ephemeris* as October 24,

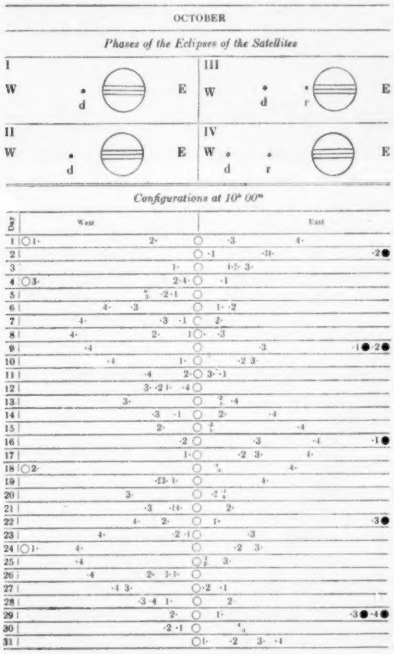
1955, 8h UT; October 31, 18h; and November 8, 3h.

The easiest way of obtaining the approximate selenographic longitude of a crater is simply to scale it off on a large lunar map. On the moon, west longitudes are positive, east longitudes negative, with the zero meridian passing nearly through the center of the apparent disk. J. A.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



On the morning of October 29th, at 7:37 UT, you can watch satellite **III** disappear in eclipse, a Jupiter diameter west of the planet. Seventy minutes later, slow-moving **IV** will be vanishing in occultation behind Jupiter's west limb.

VARIABLE STAR MAXIMA

October 1, T Columbae, 051533, 7.6; 2, X Centauri, **114441**, 7.8; 5, S Carinae, **100661**, 5.7; 17, S Ursae Majoris, 123961, 7.9; 19, R Hydrae, **132422**, 4.6; 19, RU Sagittarii, **195142**, 7.2; 23, T Ursae Majoris, 123160, 7.9; 24, T Herculis, 180531, 8.0. November 5, R Aurigae, 050953, 7.8; 7, RS Scorpii, **164844**, 6.8; 7, W Lyrae, 181136, 8.0.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MOON PHASES AND DISTANCE

Full moon	October	1, 19:17
Last quarter	October	8, 14:04
New moon	October	15, 19:32
First quarter	October	23, 23:04
Full moon	October	31, 06:04
Last quarter	November	6, 21:56

	October	Distance	Diameter
Perigee	5, 11^h	228,200 mi.	32′ 32″
Apogee	21, 06^h	251,600 mi.	29′ 31″
	November		
Perigee	2, 03^h	224,900 mi.	33′ 01″

OCTOBER METEORS

Moonlight will interfere little with observations of the Orionid meteor shower this year, at maximum on October 21st. The moon will be two days before first quarter. Under favorable conditions observers may count as many as 20 meteors per hour, after midnight when the radiant is highest. The radiant point of the swift-moving Orionids is at $5^h\ 40^m$, $+15°$, about eight degrees northwest of Betelgeuse. E. O.

MINIMA OF ALGOL

October 1, 17:12; 4, 14:01; 7, 10:50; 10, 7:39; 13, 4:28; 16, 1:16; 18, 22:04; 21, 18:53; 24, 15:42; 27, 12:31; 30, 9:20. November 2, 6:09; 5, 2:58; 7, 23:47; 10, 20:36.

These minima predictions for Algol are based on the formula in the 1953 ***International Supplement*** of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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LADY IN THE MOON

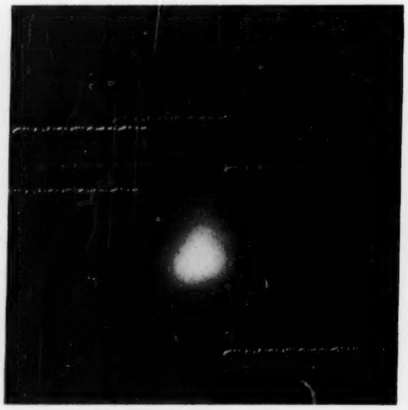
Few people, it seems, have observed the lady in the moon, so I had an artist friend touch up the shading on the accompanying photograph of the moon without materially altering the surface markings. The result is like some pictures in astronomy books of many years ago. My friends now see the face clearly even in unretouched pictures, such as the one at the left above.

The photograph was taken at the prime focus of my 6-inch f/8 reflector, at about 1/10 second on Panatomic film, developed in D76 25-per-cent overtime to increase contrast. My experience is that it is very difficult to avoid overexposure with a hand-manipulated shutter over the end of the telescope, even when the aperture is reduced to two inches. Usually I have to reduce the negatives to get good prints.

B. H. FREELAND
Bluffton, Ind.

COMET HONDA

This year's rich yield of cometary discoveries continues to grow. On the morning of July 29th, a new 8th-magnitude comet was found in Orion by the veteran Japanese comet hunter, M. Honda. The seventh discovery of the year, it was designated Comet 1955g. It moved rapidly northward, brightening as it neared the earth. According to Dr. L. E. Cunningham, Leuschner Observatory, the object passed perihelion on August 3rd, moving in an orbit tilted 82° to the earth's orbit.



The hammer-shape of the head of Comet 1955g is brought out in this 30-minute exposure on August 18-19, taken with the Curtis Schmidt telescope of the University of Michigan.

During August and September, Comet Honda's rapid motion carried it across Taurus, Auriga, Camelopardalis, Ursa Minor, Draco, and into Hercules. When the comet was nearest the earth, on August 18th, it was just visible to the naked eye. After this, as Comet Honda receded from both sun and earth, it faded rapidly, and is expected to be only magnitude 11 by October 1st.

At Stellafane, Vt., Stephen P. Maran and others, who used several telescopes, saw 1955g on August 20th as a hazy ellipse, $\frac{3}{8}$ degree long, moving visibly from hour to hour.

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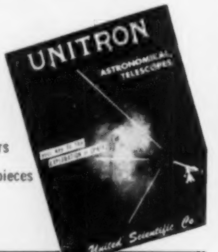

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UNITRON "Club Contest" Winners Chosen

Keen competition and intense interest characterized UNITRON's "Club Contest." As announced in the July issue, entrants were to write a letter stating what use their club would make of a UNITRON Model 114, 2.4" Altazimuth Refractor. First prize consists of a Model 114 for the club and a UNIHEX Rotary Eyepiece Selector for the writer of the most interesting and convincing letter. Ten additional prizes are awarded to the runners-up.

The overworked judges were faced with the formidable task of selecting winners among a wealth of worthy entries and the race was indeed a close one. **Stephen P. Maran,** of Brooklyn, N. Y., a member of the Brooklyn Junior Astronomy Club, was finally chosen winner of first prize. Stephen, who will be 17 in December, writes in part, "Our variable star observers, who work largely with small binoculars, but still manage to send in (collectively) several thousand observations each year to the AAVSO (American Association of Variable Star Observers), could expand their program tremendously, with hundreds of telescopic variables coming into range. Using the high-power eyepiece of the UNITRON, our double-star devotees could finally split those very close pairs which seem close to resolution in their present instruments, and the lunar-and-planetary boys, likewise fanatical in their use of high powers, could finally draw what they see, instead of what (according to certain skeptics) they would like to see. . . . Some of our members, due to geographical location or for other reasons, cannot attend the regular meetings at night. With a UNITRON, we could observe sunspots regularly, and thus hold meetings in the afternoon as well as evening, not such a common practice among astronomical societies. The attendance at our observing meetings, at present at an unfortunate low of less than 20% of the membership, would undoubtedly be greatly increased if a UNITRON were available for use by all comers at meetings. In this increased attendance lies without question the best use we could make of a UNITRON. Instead of the present hard core of experienced observers forming 90% of the members present at a meeting, some of the younger members, in the 8-12 age bracket, drawn by the exciting new instrument, would be clustered about it. And their interest and wonder and thrills at seeing for the first time, not in pictures but 'live,' the beautiful galaxies and awesome nebulae are all that anyone could expect or desire of a scientific device of any kind."

Other prize winners are: UNITRON 10x, 42-mm. view finders to **R. H. Miller,** Astronomy-Physics Club of Baltimore (Md.) City College, and **C. R. Thompson,** Regina A. S., Regina, Canada; UNITRON 200x microscopes to **J. H. Haralson,** Augusta A. C., Augusta, Ark., and **F. C. Hamner,** Shades Valley A. C., Birmingham, Ala.; UNITRON 8x, 30-mm. view finders to **T. J. Nelson, Jr.,** San Jose A. A., San Jose, Calif., and **J. L. Heilig,** Portland A. S., Portland, Ore.; UNITRON 6x, 23.5-mm. view finders to **K. B. Joice,** A. S. of Queensland, Brisbane, Australia, and **J. Martin,** Key West A. C., Key West, Fla.; and a binder for 12 copies of SKY AND TELESCOPE to **D. H. Brown, Jr.,** Sirius A. S., Chicago, Ill.

The last prize, consisting of a bottle of UNITRON's new mosquito repellent, was awarded to **V. V. Buonadona,** president of the Chicago Heights Scholastic Society for the Advancement of Science in the Fields of Pure Research and Philosophy, of Chicago Heights, Ill. Mr. Buonadona advises in part, "Set in an extensive, unilluminated field in South Chicago Heights on a clear evening the UNITRON 2.4" Altazimuth Refractor would offer an undistorted, highly-resolved view of the infinitely interesting presentations on the Sauk Trail outdoor theatre motion picture screen approximately .54 miles distant." As an additional prize, we are making arrangements to supply the savants of this organization with free tickets for the aforementioned outdoor cinema emporium where, perfumed with UNITRON's Elixir of Scorpius, they may enjoy real close-up views of Hollywood's best terrestrial nebulae.

See page 507 and the back cover.

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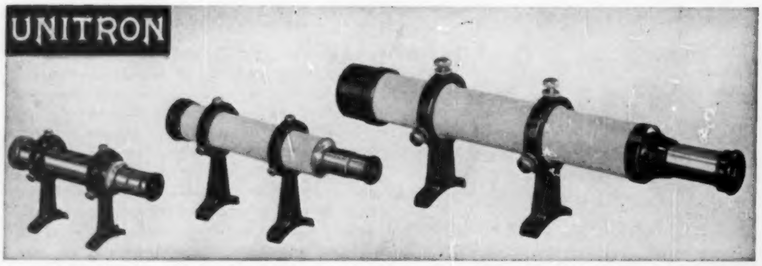

L. to R.: (1) 23.5-mm. 6x finder; (2) 30-mm. 8x finder; (3) 42-mm. 10x finder

1. VIEW FINDER (As used on UNITRON 2.4" Equatorial): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

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2. VIEW FINDER (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.

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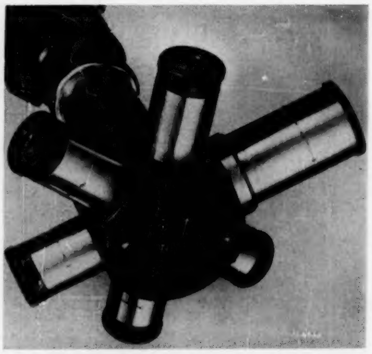

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The old-fashioned method of fumbling with eyepieces in the dark has been outmoded by UNIHEX, UNITRON's new Rotary Eyepiece Selector. With UNIHEX, you always have 6 magnifications ready at your fingertips. To change power, merely rotate a new eyepiece into position while the object stays centered and in focus in the field of view. Model A is designed to fit the UNITRON rack and pinion and is for UNITRONS only. Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet. A or B:

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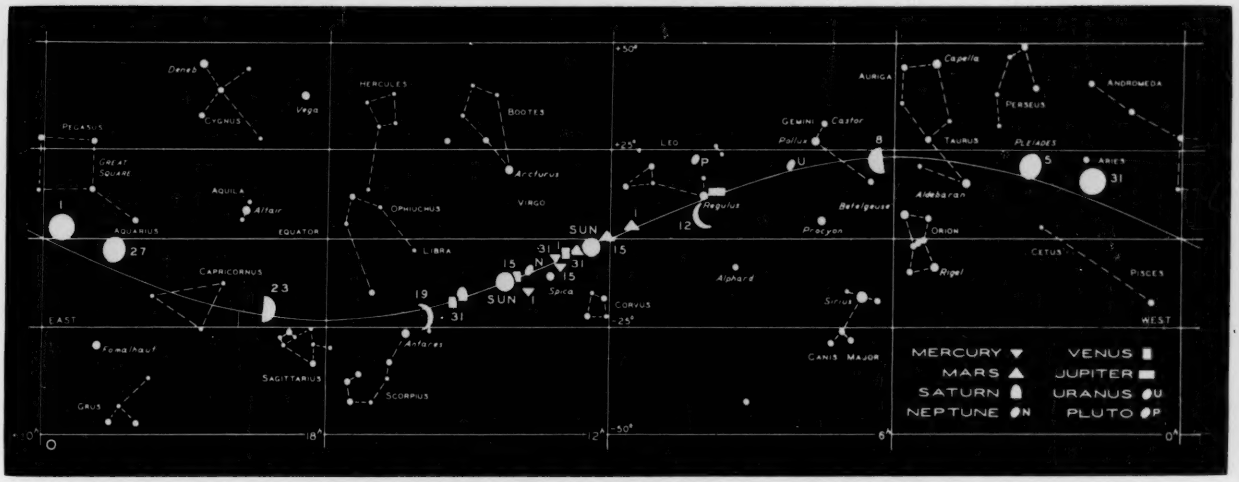


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury moves from the evening sky, through inferior conjunction with the sun on the 13th, to greatest western elongation on October 29th. It will then be 18° 33′ from the sun, rising $1\frac{1}{2}$ hours before sunrise and shining at magnitude −0.3.

Venus, moving close to the sun in the evening sky, may first be discerned at the end of October. Although setting only three quarters of an hour after the sun, Venus at magnitude −3.3 can be seen if one has a clear southwestern horizon.

Mars appears as an inconspicuous reddish 2nd-magnitude object in the morning sky. Rising two hours before the sun at the end of the month, the planet has a rapid eastward motion in Leo and Virgo.

Jupiter rises $4\frac{1}{2}$ hours before the sun on the 15th, appearing at magnitude −1.5. At the end of the month, Jupiter will be located just west of Regulus in Leo. The planet's disk will be 33″.7 in equatorial diameter in mid-October.

Saturn disappears into the sun's glare early in the month.

Uranus may be seen only during morning hours, coming to western quadrature with the sun on the 26th. Moving slowly eastward in Cancer, the planet may easily be viewed with the aid of binoculars.

Neptune passes conjunction with the sun on the 22nd and cannot be observed.

E. O.

OCCULTATION PREDICTIONS

October 27-28 **Kappa Piscium** 4.9, 23:24.6 +1-00.5, 12, Im: **A** 2:31.3 −2.8 −1.4 108; **B** 2:26.2 −2.2 −0.5 95; **C** 2:22.4 −3.3 −1.4 111; **D** 2:13.9 −2.2 +0.1 90; **E** 1:47.7 −1.9 +1.0 79; **F** 1:24.7 −2.1 +0.9 88; **I** 1:31.1 −0.4 +2.2 30.

November 1-2 **Kappa Tauri** 4.4, 4:22.7 +22-11.6, 17, Im: **A** 7:41.8 −1.7 0.0 77; **B** 7:40.6 −1.6 +0.5 66; **C** 7:33.7 −1.9 −0.3 89; **D** 7:29.8 −1.7 +0.5 73; **E** 7:06.8 −1.8 +0.6 82; **F** 6:51.0 −2.3 −0.4 108; **H** 6:20.3 −0.8 +1.7 66; **I** 6:54.9 ...... 12. Em: **A** 8:54.4 −1.3 −1.3 280; **B** 8:48.8 −1.2 −1.6 289; **C** 8:51.2 −1.6 −0.6 266; **D** 8:43.5 −1.5 −1.1 280; **E** 8:25.9 −1.9 −0.1 266; **F** 8:04.1 −2.1 +1.8 234; **H** 7:29.2 −1.7 +0.8 270; **I** 7:20.7 ...... 327.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

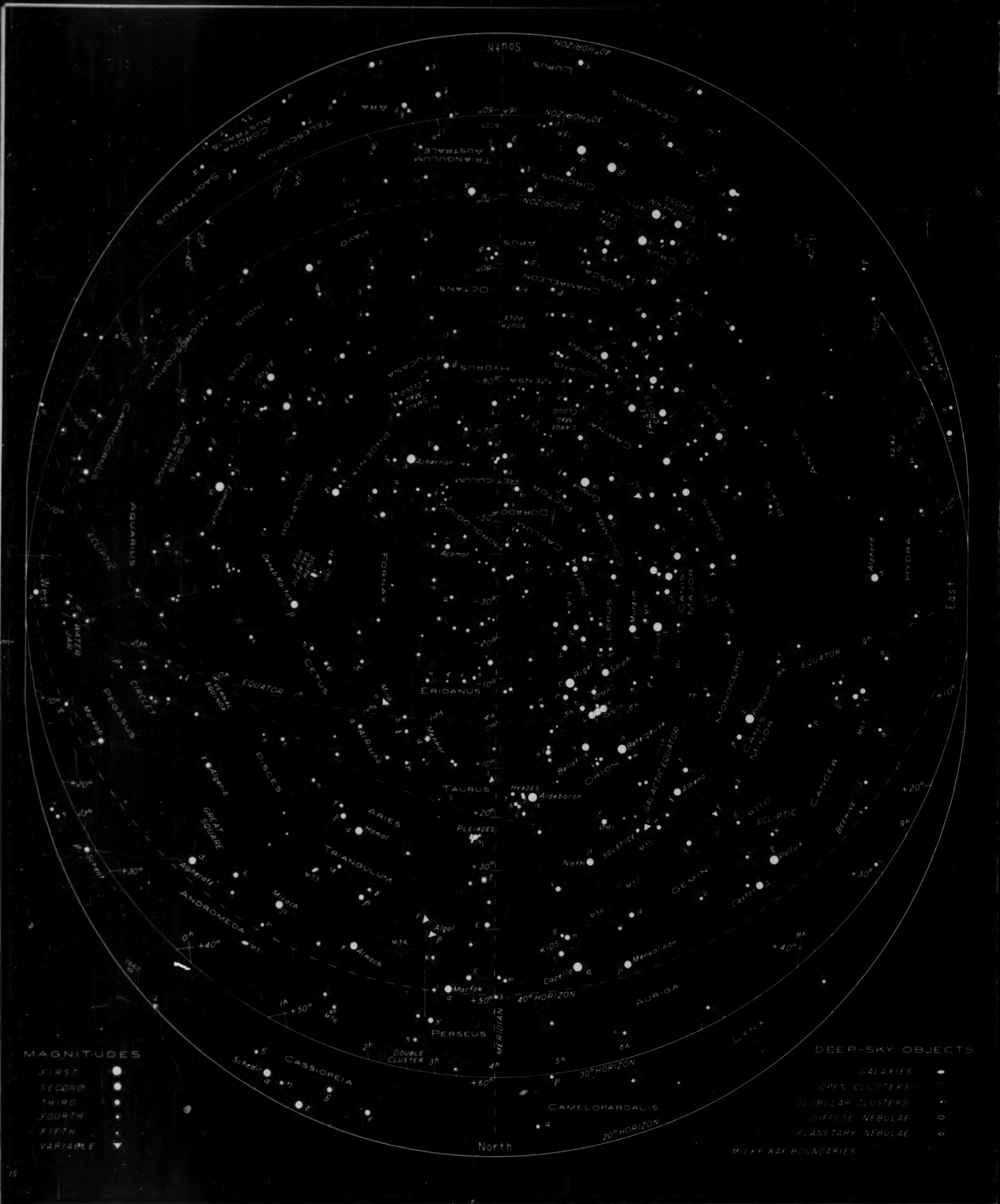
A	+72°.5,	+42°.5	E	+91°.0,	+40°.0
B	+73°.6,	+45°.5	F	+98°.0,	+31°.0
C	+77°.1,	+38°.9	G	Discontinued	
D	+79°.4,	+43°.7	H	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Eunomia, 15, 7.5. Oct. 10, 2:49.8 +36-46; 20, 2:42.9 +36-53; 30, 2:33.9 +36-25. Nov. 9, 2:24.3 +35-24; 19, 2:15.8 +33-56; 29, 2:09.8 +32-15.

Palatia, 415, 9.6. Oct. 10, 2:51.9 +0-40; 20, 2:47.4 −0-26; 30, 2:40.7 −1-22. Nov. 9, 2:33.1 −1-56; 19, 2:26.2 −2-00; 29, 2:21.7 −1-32.

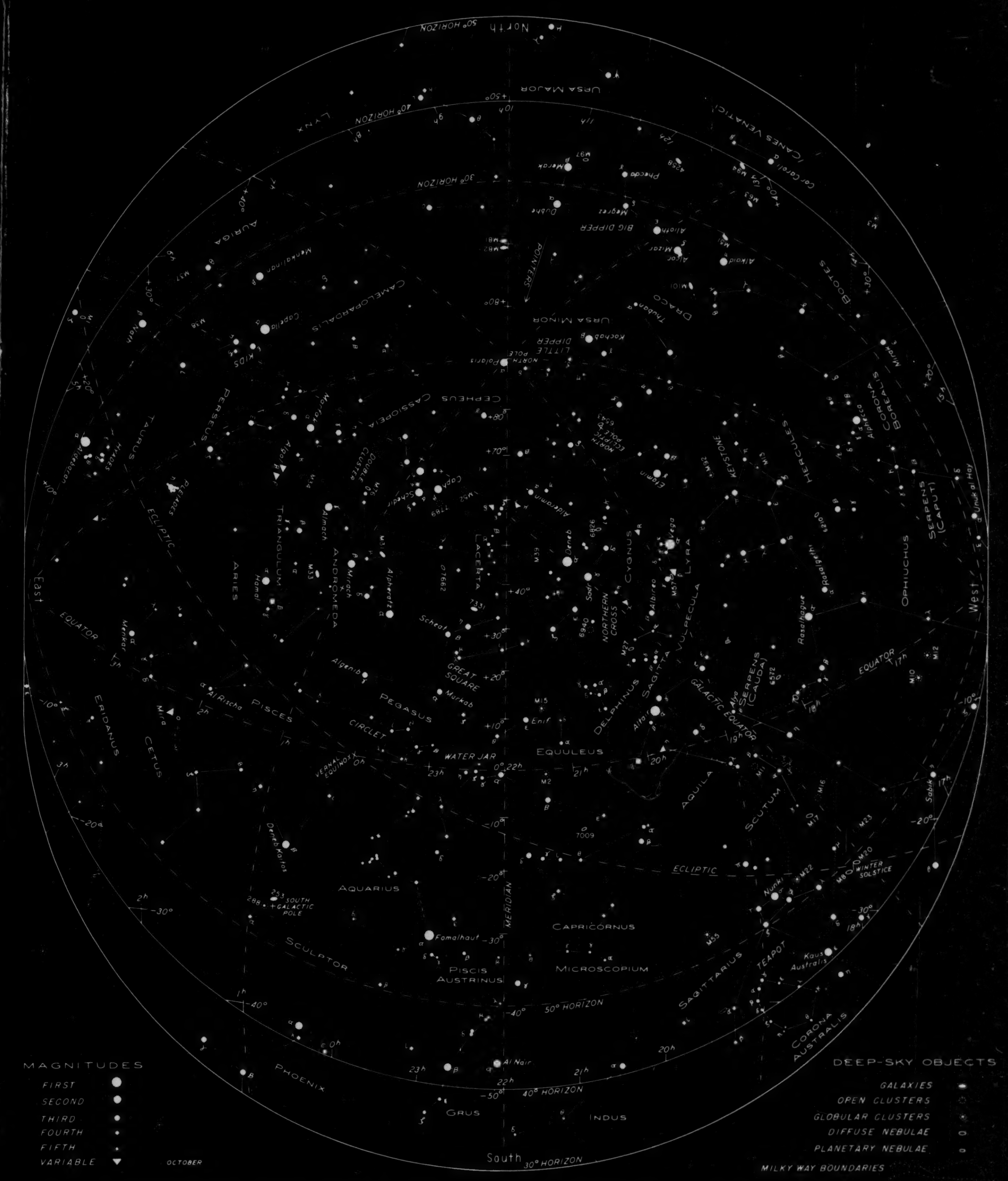
After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of December; also, at 9 p.m. and 8 p.m. on January 7th and 23rd. For other dates, add or subtract ½ hour per week. When facing south, hold "South" at the bottom; turn the chart to observe in other directions.

The full length of the river, Eridanus, winding near the meridian, may be traced from 1st-magnitude Achernar, ninth brightest star in the entire sky, to 3rd-magnitude Beta, near Rigel.



STARS FOR OCTOBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of October, respectively; also 7 p.m. on November 7th. For other dates, add or subtract ½ hour per week.

Delta (δ) Cephei, the prototype of Cepheid variable stars, is on the meridian at chart time this month. This star varies in brightness by a small amount, changing from magnitude 3.6 to 4.3 and back again every 5⅓ days, in a cycle repeated with great regularity.

DEEP-SKY WONDERS

TO THINK of Pegasus is to think of its great globular cluster M15, at $21^h\ 27^m.6$, $+11°\ 57'$ (1950 co-ordinates). This 6th-magnitude object, NGC 7078, is a bright, compact ball of stars, resolvable at the edges. For those who seek more difficult objects we offer several galaxies. All but one have been seen with 4-inch telescopes under excellent conditions, but they are no mean feat for a 6-inch. The accompanying finder charts will help.

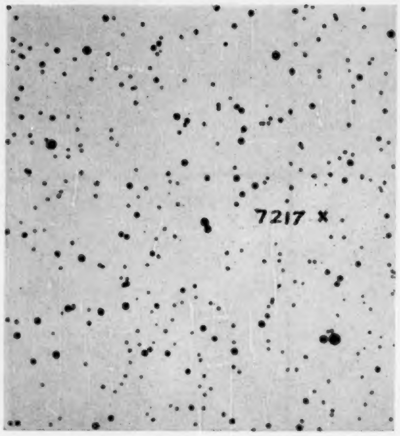
The spiral galaxy NGC 7217, at $22^h\ 05^m.6$, $+31°\ 07'$, is $.3'$ by $1'$ in angular size, and about magnitude 11. William Herschel discovered it in 1784 with a 19-inch f/13 reflector, describing it as "faint, rather large, round, and gradually brighter toward the middle."

NGC 7331, at $22^h\ 34^m.8$, $+34°\ 10'$, is a spiral seen edgewise, $9'$ by $2'$ (not charted here). At magnitude 10, it is the brightest of this month's selections.

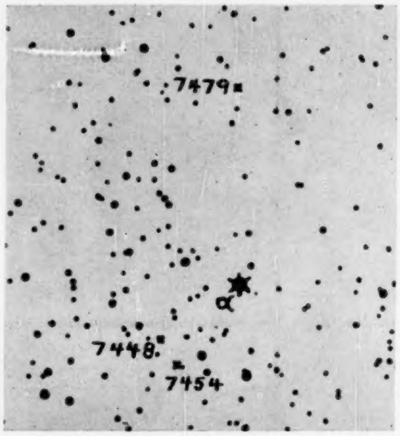
Two galaxies that lie hardly an eyepiece field from Alpha Pegasi are most convenient for the observer who wishes to try his luck at the fainter objects in the sky. NGC 7448 ($22^h\ 57^m.6$, $+15°\ 43'$) is magnitude 11 and so small, $2'$ by $1'$, that it will be hard to identify with powers under about 50x. Nearby, at $22^h\ 58^m.6$, $+16°\ 10'$, lies NGC 7454, fainter than magnitude 13 and less than one minute in diameter. I have seen it in a good 10-inch, but not with less aperture.

Farther south is NGC 7479, a barred spiral at $23^h\ 02^m.4$, $+12°\ 03'$. Its magnitude is $11\frac{1}{2}$. Its size has been measured as $3'$ by $2\frac{1}{2}'$ from long-exposure photographs, but in small telescopes it appears more elongated than these diameters suggest. A 5-inch shows it under optimum conditions, but a 10-inch does better.

WALTER SCOTT HOUSTON



South is above on these 6°-by-6° finder charts, showing stars to magnitude 9.



SUNSPOT NUMBERS

July 1, 35, 35; **2,** 42, 38; **3,** 42, 38; **4,** 46, 43; **5,** 45, 48; **6,** 51, 60; **7,** 55, 47; **8,** 42, 47; **9,** 32, 39; **10,** 35, 41; **11,** 18, 35; **12,** 21, 25; **13,** 27, 25; **14,** 28, 37; **15,** 20, 29; **16,** 10, 22; **17,** 7, 20; **18,** 1, 7; **19,** 25, 26; **20,** 27, 32; **21,** 14, 11; **22,** 11, 9; **23-24,** 0, 0; **25,** 1, 8; **26,** 2, 0; **27,** 10, 11; **28,** 12, 12; **29,** 17, 16; **30,** 22, 20; **31,** 21, 26. Means for July, 23.2 American; 26.0 Zurich.

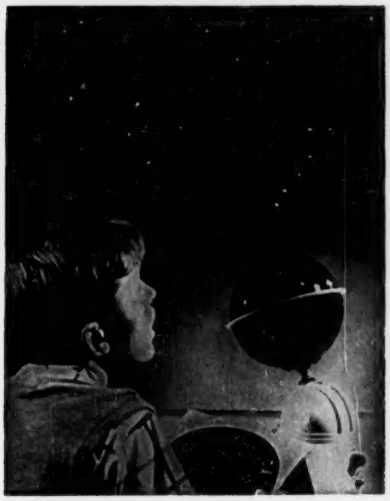
Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

Spitz Jr. Planetarium

No. 701 Spitz Junior Planetarium. A new visual teaching aid brings a knowledge of the heavens into your classroom or home. A plastic globe is perforated with small apertures and contains a pinpoint light source inside. Stars and constellations are projected on the ceiling; a dome is helpful, but not necessary. Adjustable for date and latitude. Size 14½″ high, 7½″ square base. Weight 3 lbs. Operates on 110-volts. Complete with 32-page star guide. **$15.00**



Celestial Globes

No. 740-5 Deluxe Celestial Globe. Our finest 16″ globe was designed as a visual aid by teaching astronomers. All stars of the first six magnitudes are shown on a pale blue background, with the first three magnitudes having bright yellow circular backgrounds. Brighter stars named and constellation boundaries indicated. Declination and right ascension circles printed in black. Magellanic Clouds and Milky Way stand out in white; important star clusters indicated. Weighted table base, movable meridian with horizon. (Other mountings available.) **$67.50**

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No. 732 Little Dipper Globe. A teaching aid that is designed to introduce the wonders of the heavens to all youngsters, and it will fascinate grown-ups too. The all-metal 6″ celestial globe brings out the mythological background of the constellations in five brilliant colors and shows all major stars and constellations, the equator and the ecliptic. A meridian circle and a convenient base are included. Popular 155-page book "Stars" in full color is included to give further material on the mysteries of astronomy. Overall height 8½″; shipping weight 2½ lbs. **$4.00**

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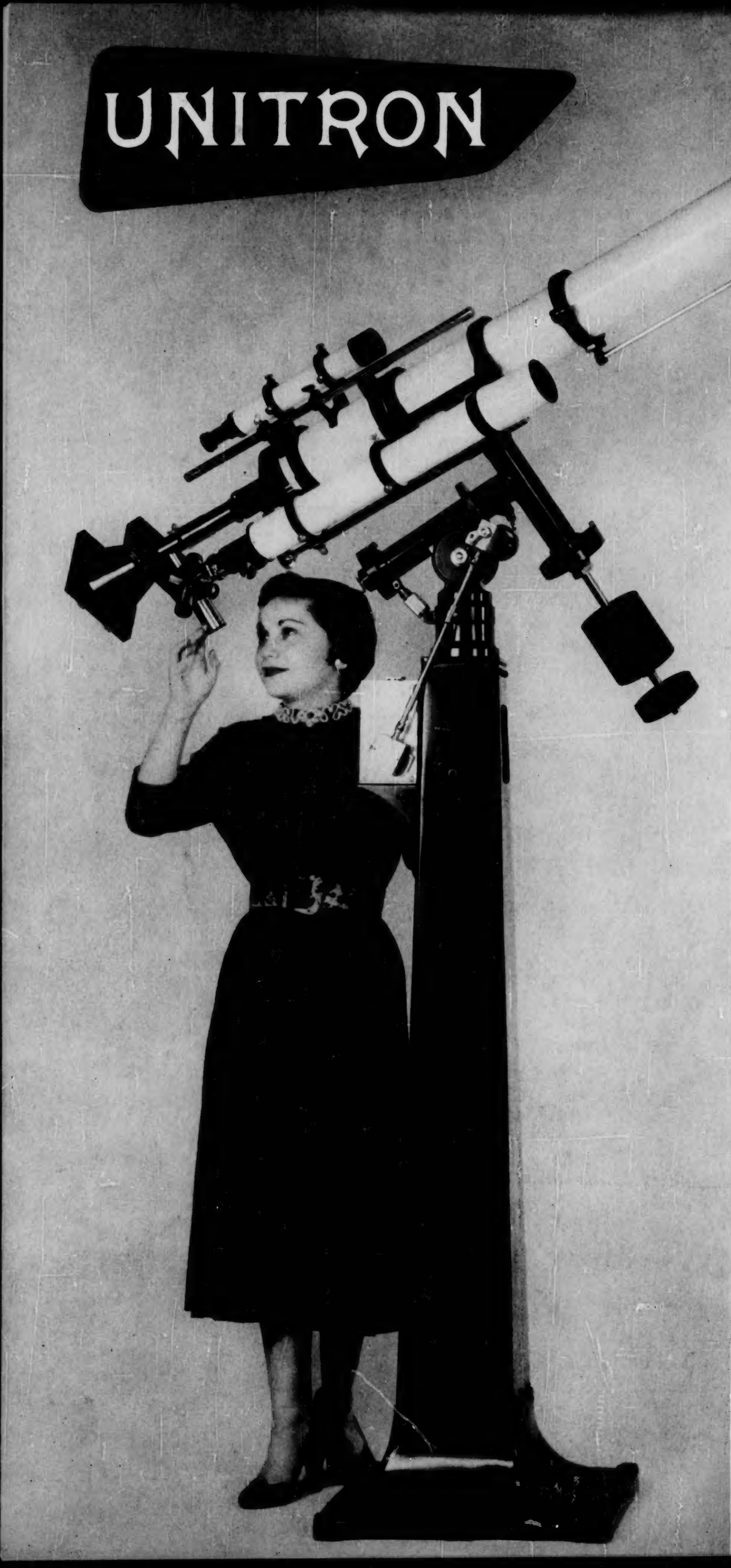

See pages 507 and 522.